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Decoupled formulation of constraints on adaptive hanging nodes in EUROPLEXUS

Folco Casadei
Martin Larcher
Georgios Valsamos
Vincent Faucher

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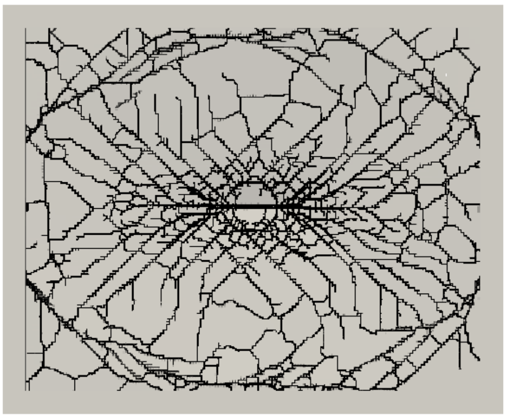

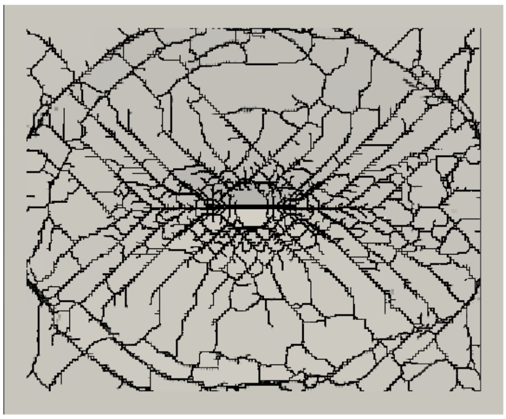

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Contact information
Georgios Valsamos
Address: Joint Research Centre, Via Enrico Fermi 2749, TP 480, 21027 Ispra (VA), Italy
E-mail: georgios.valsamos@jrc.ec.europa.eu
Tel.: +39 0332 78 9004
Fax: +39 0332 78 9049

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Abstract

The present report introduces the possibility of formulating the constraints on so-called "hanging" nodes which arise in adaptivity in a decoupled manner, rather than by using the standard, fully coupled treatment. The scope is to try reduce the CPU time required in some complex 3D applications, including those using adaptivity in shell elements. In these applications, when the number of hanging constraints may become huge and the (implicit) solution of the fully coupled problem may either require a large CPU time, if using the standard solver (Cholesky method), or may occasionally fail when using special solvers which are in principle more efficient.

Technical Note

2015

Decoupled formulation of constraints on adaptive hanging nodes in EUROPLEXUS

F. Casadei, M. Larcher, G. Valsamos
European Commission,
Institute for the Protection and Security of the Citizen
Joint Research Centre, 21020 Ispra, Italy

V. Faucher
CEA - Saclay (F)

16 August 2015

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1. Introduction

This report is a sequel to reports and publications [1-17] on mesh adaptivity in fast transient dynamics and introduces a decoupled formulation for the links arising at adaptive hanging nodes. The algorithms mentioned here are implemented in the EUROPLEXUS code.

EUROPLEXUS [20] is a computer code for fast explicit transient dynamic analysis of fluid-structure systems jointly developed by the French Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA Saclay) and by the Joint Research Centre of the European Commission (JRC Ispra).

Reference [1] presented the first implementation in EUROPLEXUS of an adaptive mesh refinement and un-refinement procedure, in two space dimensions (element shape QUA4) for solid mechanics. The procedure was extended to fluid mechanics (FE formulation) in 2D in reference [2]. Then, reference [3] applied a similar refinement and un-refinement procedure in three space dimensions to the CUB8 element shape, both in solids mechanics and in fluid mechanics (FE formulation).

All numerical examples presented in references [1-3] with a variable mesh used a so-called "manual" mesh adaptation directive, the `WAVE` directive (see the code manual in reference [20]), first introduced in reference [1]. This directive refines the mesh along "wavefronts" that are specified by the user, e.g. according to a known analytical solution to the problem considered. This technique was used with success to simulate a bar problem (in solid mechanics) and a shock tube problem (in fluid mechanics) both in 2D and in 3D [1-3].

However, those solutions cannot be qualified as "true" adaptive solutions, because in (true) adaptivity mesh refinement and un-refinement should be completely automatic, based upon suitable *error estimators* or *error indicators*. The formulation of error estimators in fast transient dynamics is challenging and is still a subject of research. The use of so-called error indicators, however, is much simpler. For this reason, subsequent work in EUROPLEXUS focused on error indicators. References [4] and [5] document a first prototype implementation of adaptivity based upon error indicators in EUROPLEXUS, limited to 2D problems in continuum and fluid mechanics. An extension of the indicator technique to 3D is under development but has not been completed and documented yet.

Publications [6-7] focus on the natural quantities of interest in goal-oriented error assessment and adaptivity, but limited to the case of linear elasto-dynamics.

The adaptive technique was then applied to Cell-Centred Finite Volumes (CCFV) for the description of the fluid domain, first in 2D (see [8]) and then also in 3D [9]. More recently, the technique has also been extended for use with the CDEM combustion model which makes use of the CCFV formulation [10]. A complete description of the element refinement and un-refinement techniques used in mesh adaptation has been published in a paper [11].

A first contribution towards combination of mesh adaptivity with Fluid-Structure Interaction (FSI) was given in reference [12], in which a model is described that automatically refines the fluid mesh in the vicinity of an embedded structure which can move and deform until and beyond rupture (but without being itself subjected to adaptivity).

In [13] adaptivity was activated for simplex elements (triangles in 2D and tetrahedra in 3D). The report [14] extends adaptivity to CEA's family of fluid elements. Reference [15] extends adaptivity to shell, beam and bar structural elements. It becomes therefore possible to have mesh adaptivity both in a fluid and at the same time in a structure (typically made of shells) embedded in the fluid.

Reference [16] extends the automatic fluid mesh adaptation of reference [12] to the case where adaptation of the structure according to the techniques described in [15] occurs simultaneously. This technique is particularly useful in conjunction with FSI algorithms of the *embedded* or *immersed* type, such as the FLSR or FLSW algorithms available in EUROPLEXUS.

Finally, reference [17] addresses the post-processing and the correct interpretation of results obtained in numerical simulations using mesh adaptivity.

The present report introduces the possibility of formulating the constraints on so-called "hanging" nodes which arise in adaptivity in a decoupled manner, rather than by using the standard, fully-coupled treatment. The scope is to try reduce the CPU time required in some complex 3D applications, especially those using adaptivity in shell elements. In these applications, when the number of hanging nodes is very large, the number of hanging constraints may become huge and the (implicit) solution of the fully coupled problem may either require a large CPU time, if using the standard solver (Cholesky method), or may occasionally fail when using special solvers which are in principle more efficient (SPLIB, Pardiso).

The present document is organized as follows:

- Section 2 discusses the potential problems related to the fully coupled treatment of hanging constraints, and then proposes methodologies to treat them in a decoupled manner, by accepting some approximations in the solution.
- Section 3 presents some numerical examples for the verification of the proposed methodologies

The Appendix contains a listing of all the input files mentioned in the present report.

2. Treatment of hanging constraints

So-called “hanging” nodes appear in adaptive meshes in the zones where the mesh size varies [1], see e.g. Figure 1 for a simple example in 2D. The hanging node H is not completely free. Its motion depends upon the motion of the “master” nodes (I and J in this case), in order to preserve continuity of the solution across the non-conforming (internal) boundary of the mesh. Note that a hanging node is always a descendant (not base) node, while master nodes can be either base nodes or descendant nodes, and in the latter case they may be themselves hanging upon other nodes.

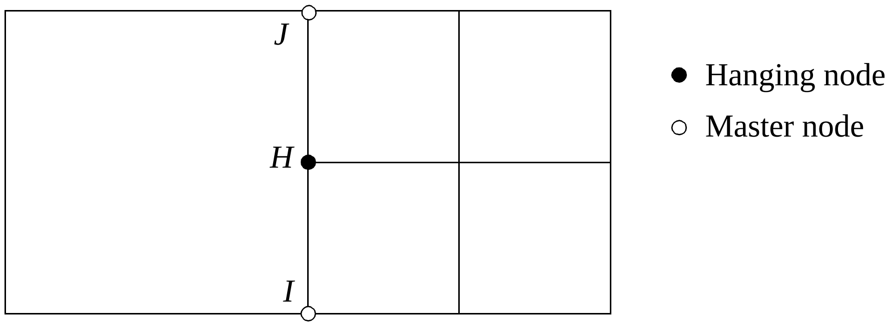

Figure 1 - Example of hanging node in 2D

2.1 Constraints on hanging nodes

At a generic hanging node H, we impose a set of constraints which are typically expressed upon (the new mid-step) velocities [1]:

$$\underline{v}_H^{n+3/2} = \sum_{K=1}^{N} c_K \underline{v}_K^{n+3/2} \tag{1}$$

where K are the master nodes and c_K are some (constant) coefficients. For example, in the case of Figure 1 we have:

$$\underline{v}_H^{n+3/2} = \frac{1}{2}\underline{v}_I^{n+3/2} + \frac{1}{2}\underline{v}_J^{n+3/2} \tag{2}$$

The vector equation (2) represents two (independent) scalar relations, one along the x-axis and the other along the y-axis, since we are in 2D and the elements used are continuum elements, with just 2 degrees of freedom (dofs) per node. In the 3D case and/or in the case of structural (shell/bar/beam) elements, more dofs per node are involved. In EPX at the time of this writing the number N of master nodes can be either 2 or 4. The latter case occurs in 3D for continuum-element nodes (hexahedra) hanging upon an internal (quadrilateral) face. When a tetrahedron is split [13], only mid-corner nodes and no mid-face nodes are created, so that there is no need to treat the case $N = 3$.

Note, incidentally, that hanging constraints are not required at hanging nodes belonging to cell-centred finite volumes (VFCC) used for fluid modelling, since for such “elements” all quantities (including the velocities) are discretized at the volume centre. They are required with structural (Finite) elements and with Finite Elements used for fluid modelling.

2.2 Fully coupled treatment by Lagrange multipliers

By default, in EPX hanging constraints are treated as non-permanent links by means of the fully coupled formulation of Lagrange multipliers. The links are non-permanent because a hanging node may become non-hanging during the transient calculation if all neighboring elements are refined.

This means that relations (links) of the type (1) are written (one for each concerned dof) at each time step and added to the global system of links, which is solved implicitly by the method of Lagrange multipliers, see e.g. references [18-19].

This ensures that the imposed constraints are “exactly” satisfied, and this compatibly with any other constraints that the user might have imposed on the nodes. However, since the hanging nodes are descendant ones, it is unlikely (or even technically impossible) that the user has prescribed any constraint directly on such nodes. This is not the case for boundary-hanging (B-hanging) nodes, i.e. hanging nodes created along the boundary of the adapted domain, but constraints on B-hanging nodes are always imposed in a fully coupled manner and are not considered in the present work.

In some large 3D applications, especially when adaptivity in shell elements is activated, the number of hanging nodes can be large. Therefore the number of hanging constraints is also large, since there are typically 6 dofs (and therefore 6 constraints) per shell node in 3D. Sometimes the solution of the coupled system may become CPU-time consuming, if one uses the standard Cholesky solver, or even fail if one attempts to use a “fast” solver such as SPLIB or Pardiso.

In such cases it would be nice to have at disposal an uncoupled treatment of hanging links, allowing for fast and straightforward solution. Obviously, any uncoupled solution of the hanging constraints introduces some approximations, since such constraints are indeed coupled, in reality. See for example Figure 2 where both hanging nodes H_1 and H_2 share the same master node J. However, the approximations introduced might be acceptable in view of the gain in CPU time.

In the following, several possible ways of de-coupling the treatment of links are investigated.

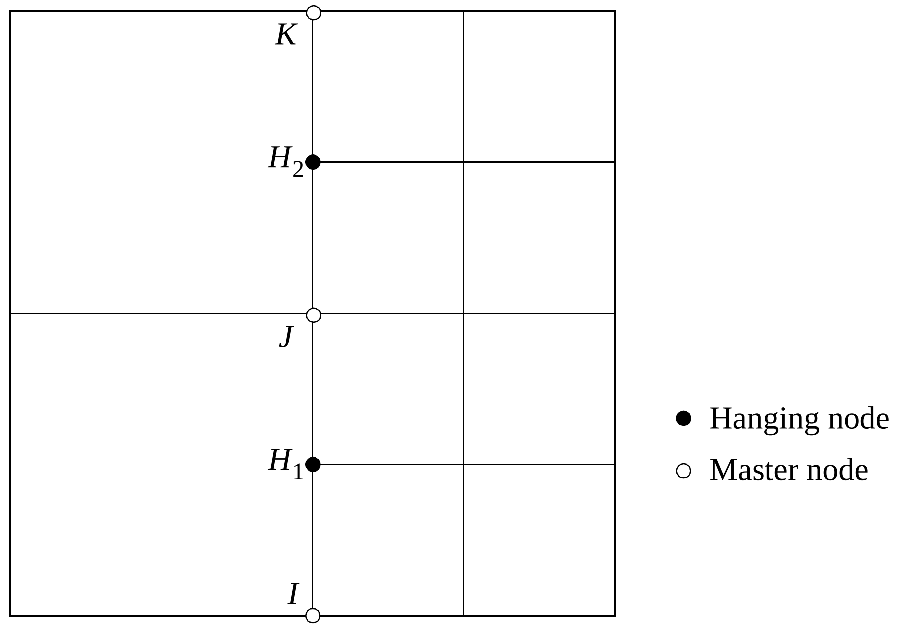

Figure 2 - Example of several hanging nodes in 2D

2.3 Decoupled treatment by Lagrange multipliers on velocities

A first and straightforward possibility of decoupling the treatment of hanging links is to solve each constraint (1) independently from the others (and this of course independently along each spatial direction) instead of adding them to the system of links.

By following reference [19], Section 4.6 (Treatment of a single independent link), we proceed as follows. In the general case, the coupling equation may be written as:

$$c_1 v_1 + c_2 v_2 + \dots + c_N v_N = b \tag{3}$$

where we have assumed just one (independent) link involving N dofs $v_1, v_2, \dots, v_N$ through some coefficients $c_1, c_2, \dots, c_N$. For generality, we consider also a non-zero right-hand side b.

We pose:

$$\begin{aligned} \underline{C} &= \begin{bmatrix} c_1 & c_2 & \dots & c_N \end{bmatrix} \\ \underline{v} &= \begin{bmatrix} v_1 & v_2 & \dots & v_N \end{bmatrix}^T \\ \underline{b} &= \begin{bmatrix} b \end{bmatrix} \end{aligned} \tag{4}$$

Equilibrium (of the constrained dofs) is expressed by:

$$\mathrm{diag}\begin{bmatrix} m_1 & m_2 & \dots & m_N \end{bmatrix}\begin{bmatrix} a_1 \\ a_2 \\ \dots \\ a_n \end{bmatrix} = \begin{bmatrix} f_1 \\ f_2 \\ \dots \\ f_n \end{bmatrix} + \begin{bmatrix} r_1 \\ r_2 \\ \dots \\ r_n \end{bmatrix} \tag{5}$$

where m are the nodal masses, a are the nodal accelerations, f are the net nodal forces (external forces minus internal forces) and r are the nodal reactions. The (unknown) reaction forces are expressed, without loss of generality, in terms of the Lagrange multiplier (a scalar in this case):

$$\begin{bmatrix} r_1 \\ r_2 \\ \dots \\ r_n \end{bmatrix} = \underline{C}^T\underline{\lambda} = \begin{bmatrix} c_1 \\ c_2 \\ \dots \\ c_n \end{bmatrix}\begin{bmatrix} \lambda \end{bmatrix} \tag{6}$$

The expression of $\underline{C}\underline{a}$ (see reference [19])

$$\underline{C}\underline{a} = \frac{2}{\Delta t^n + \Delta t^{n+1}}(\underline{b} - \underline{C}\underline{v}^{n+1/2}) \tag{7}$$

becomes

$$\underline{C}\underline{a} = \begin{bmatrix} c_1 & c_2 & \dots & c_N \end{bmatrix}\begin{bmatrix} a_1 \\ a_2 \\ \dots \\ a_n \end{bmatrix} = \frac{2}{(\Delta t^n + \Delta t^{n+1})}\left(\begin{bmatrix} b \end{bmatrix} - \begin{bmatrix} c_1 & c_2 & \dots & c_N \end{bmatrix}\begin{bmatrix} v_1^{n+1/2} \\ v_2^{n+1/2} \\ \dots \\ v_N^{n+1/2} \end{bmatrix}\right) = \frac{2(b - c_1 v_1^{n+1/2} - c_2 v_2^{n+1/2} - \dots - c_N v_N^{n+1/2})}{(\Delta t^n + \Delta t^{n+1})} \tag{8}$$

where $\Delta t^n = t^{n+1} - t^n$ is the time step that has led to the current configuration (x^{n+1}) while $\Delta t^{n+1} = t^{n+2} - t^{n+1}$ is the new time step.

The expression of $\underline{C}\underline{m}^{-1}$ reduces to:

$$\underline{C}\underline{m}^{-1} = \begin{bmatrix} c_1 & c_2 & \dots & c_N \end{bmatrix}\mathrm{diag}\begin{bmatrix} \frac{1}{m_1} & \frac{1}{m_2} & \dots & \frac{1}{m_N} \end{bmatrix} = \begin{bmatrix} \frac{c_1}{m_1} & \frac{c_2}{m_2} & \dots & \frac{c_N}{m_N} \end{bmatrix} \tag{9}$$

and $\underline{C}\underline{m}^{-1}\underline{C}^T$ is:

$$\underline{C}\underline{m}^{-1}\underline{C}^T = \begin{bmatrix} \frac{c_1}{m_1} & \frac{c_2}{m_2} & \dots & \frac{c_N}{m_N} \end{bmatrix} \begin{bmatrix} c_1 \\ c_2 \\ \dots \\ c_n \end{bmatrix} = \frac{c_1^2}{m_1} + \frac{c_2^2}{m_2} + \dots + \frac{c_N^2}{m_N} \tag{10}$$

Then:

$$\underline{C}\underline{m}^{-1}(\underline{f}_e - \underline{f}_i) = \underline{C}\underline{m}^{-1}\underline{f} = \begin{bmatrix} \frac{c_1}{m_1} & \frac{c_2}{m_2} & \dots & \frac{c_N}{m_N} \end{bmatrix} \begin{bmatrix} f_1 \\ f_2 \\ \dots \\ f_n \end{bmatrix} = c_1\frac{f_1}{m_1} + c_2\frac{f_2}{m_2} + \dots + c_N\frac{f_N}{m_N} \tag{11}$$

Next, we get:

$$\left(\frac{c_1^2}{m_1} + \frac{c_2^2}{m_2} + \dots + \frac{c_N^2}{m_N}\right)\lambda = \frac{2(b - c_1 v_1^{n+1/2} - c_2 v_2^{n+1/2} - \dots - c_N v_N^{n+1/2})}{(\Delta t^n + \Delta t^{n+1})} - c_1\frac{f_1}{m_1} - c_2\frac{f_2}{m_2} - \dots - c_N\frac{f_N}{m_N} \tag{12}$$

and from this the Lagrange multiplier is obtained as:

$$\lambda = \frac{\dfrac{2(b - c_1 v_1^{n+1/2} - c_2 v_2^{n+1/2} - \dots - c_N v_N^{n+1/2})}{(\Delta t^n + \Delta t^{n+1})} - c_1\dfrac{f_1}{m_1} - c_2\dfrac{f_2}{m_2} - \dots - c_N\dfrac{f_N}{m_N}}{\left(\dfrac{c_1^2}{m_1} + \dfrac{c_2^2}{m_2} + \dots + \dfrac{c_N^2}{m_N}\right)} \tag{13}$$

Finally the reactions result in:

$$r_1 = c_1\lambda \qquad r_2 = c_2\lambda \qquad \dots \qquad r_N = c_N\lambda \tag{14}$$

2.4 Decoupled treatment by Lagrange multipliers on displacements

Solving the velocity constraints independently as proposed in the previous Section risks to lead to error cumulation in the position of hanging nodes over time. An alternative possibility is to formulate the (decoupled) links using the displacements rather than the velocities.

If the constraints are enforced in a coupled (and therefore “exact”) way, then using velocities or displacements leads to the same solution, since when a hanging node is first created both its displacement and its velocity are interpolated from those of the master nodes so as to satisfy the constraint. However, the same is not true if the constraints are imposed in a decoupled (and only approximated) way.

We assume that the constraints on the current displacements ($\underline{d}^{n+1}$) are satisfied, and impose the constraint on the next displacements ($\underline{d}^{n+2}$), i.e. we replace eq. (3) by:

$$\underline{C}^{n+2}\underline{d}^{n+2} = \underline{b}^{n+2} \tag{15}$$

Equilibrium for the constrained dofs (at $n+1$) is given by:

$$\underline{m}^{n+1}\underline{a}^{n+1} = \underline{F}_E^{n+1} - \underline{F}_I^{n+1} + \underline{r}^{n+1} \tag{16}$$

where $\underline{F}_E$ are the external forces and $\underline{F}_I$ are the internal forces. From now on we drop the suffix $n+1$ for the current quantities. We express the unknown reactions in function of Lagrange multipliers via the matrix of constraints (at $n+2$):

$$\underline{r} = \underline{C}^{T,\,n+2}\underline{\lambda} \tag{17}$$

which substituted in (16) gives:

$$\underline{m}\underline{a} = \underline{F}_E - \underline{F}_I + \underline{C}^{T,\,n+2}\underline{\lambda} \tag{18}$$

We multiply both members by $\underline{C}^{n+2}\underline{m}^{-1}$ obtaining:

$$\underline{C}^{n+2}\underline{a} = \underline{C}^{n+2}\underline{m}^{-1}(\underline{F}_E - \underline{F}_I) + \underline{C}^{n+2}\underline{m}^{-1}\underline{C}^{T,\,n+2}\underline{\lambda} \tag{19}$$

From the central difference time integration scheme used in EPX we obtain:

$$\begin{aligned} \underline{d}^{n+2} &= \underline{d} + \Delta t^{n+1}\underline{v}^{n+3/2} \\ \underline{v}^{n+3/2} &= \underline{v}^{n+1/2} + \frac{\Delta t^n + \Delta t^{n+1}}{2}\underline{a} \end{aligned} \tag{20}$$

that is:

$$\underline{d}^{n+2} = \underline{d} + \Delta t^{n+1}\underline{v}^{n+1/2} + \Delta t^{n+1}\frac{\Delta t^n + \Delta t^{n+1}}{2}\underline{a} \tag{21}$$

By replacing this into (15) we obtain:

$$\underline{C}^{n+2}\underline{d} + \underline{C}^{n+2}\Delta t^{n+1}\underline{v}^{n+1/2} + \underline{C}^{n+2}\Delta t^{n+1}\frac{\Delta t^n + \Delta t^{n+1}}{2}\underline{a} = \underline{b}^{n+2} \tag{22}$$

and from this:

$$\underline{C}^{n+2}\underline{a} = \frac{2}{\Delta t^{n+1}(\Delta t^n + \Delta t^{n+1})}(\underline{b}^{n+2} - \underline{C}^{n+2}\underline{d} - \underline{C}^{n+2}\Delta t^{n+1}\underline{v}^{n+1/2}) \tag{23}$$

From this and from (19) we get:

$$\underline{C}^{n+2}\underline{m}^{-1}\underline{C}^{T,\,n+2}\underline{\lambda} = \frac{2}{\Delta t^{n+1}(\Delta t^n + \Delta t^{n+1})}(\underline{b}^{n+2} - \underline{C}^{n+2}\underline{d} - \underline{C}^{n+2}\Delta t^{n+1}\underline{v}^{n+1/2}) - \underline{C}^{n+2}\underline{m}^{-1}(\underline{F}_E - \underline{F}_I) \tag{24}$$

or:

$$\underline{B}^{*}\underline{\lambda} = \underline{W} \tag{25}$$

having posed:

$$\begin{aligned} \underline{B}^{*} &= \underline{C}^{n+2}\underline{m}^{-1}\underline{C}^{T,\,n+2} \\ \underline{W} &= \frac{2}{\Delta t^{n+1}(\Delta t^{n} + \Delta t^{n+1})}(\underline{b}^{n+2} - \underline{C}^{n+2}\underline{d} - \underline{C}^{n+2}\Delta t^{n+1}\underline{v}^{n+1/2}) - \underline{C}^{n+2}\underline{m}^{-1}(\underline{F}_{E} - \underline{F}_{I}) \end{aligned} \tag{26}$$

Since the quantities at $n+2$ are not known yet, we have to assume that:

$$\begin{aligned} \underline{C}^{n+2} \approx \underline{C}^{n+1} &= \underline{C} \\ \underline{m}^{n+2} \approx \underline{m}^{n+1} &= \underline{m} \\ \underline{b}^{n+2} \approx \underline{b}^{n+1} &= \underline{b} \end{aligned} \tag{27}$$

The first relation is exact for the hanging links since the coefficients of $\underline{C}$ are constant in time. The second relation is exactly satisfied for the translational dofs of structures (but not in general for rotational dofs), but not for fluids if a non-Lagrangian formulation is adopted. The third relation is exactly satisfied for hanging constraints since $\underline{b}$ is constant in time ($\underline{b} = \underline{0}$).

These assumptions allow us to write (24) as:

$$\underline{C}\underline{m}^{-1}\underline{C}^{T}\underline{\lambda} = \frac{2}{\Delta t^{n+1}(\Delta t^{n} + \Delta t^{n+1})}(\underline{b} - \underline{C}\underline{d} - \underline{C}\Delta t^{n+1}\underline{v}^{n+1/2}) - \underline{C}\underline{m}^{-1}(\underline{F}_{E} - \underline{F}_{I}) \tag{28}$$

Now let us consider (28) as a single de-coupled (independent) link. We have:

$$S_3 = \underline{C}\underline{m}^{-1}\underline{C}^{T} = \left(\frac{c_1^2}{m_1} + \frac{c_2^2}{m_2} + \ldots + \frac{c_N^2}{m_N}\right) \tag{29}$$

$$S_2 = \underline{C}\underline{m}^{-1}(\underline{F}_{E} - \underline{F}_{I}) = \left(\frac{c_1 F_1}{m_1} + \frac{c_2 F_2}{m_2} + \ldots + \frac{c_N F_N}{m_N}\right) \tag{30}$$

$$\begin{aligned} S_1 &= \frac{2}{\Delta t^{n+1}(\Delta t^{n} + \Delta t^{n+1})}(\underline{b} - \underline{C}\underline{d} - \underline{C}\Delta t^{n+1}\underline{v}^{n+1/2}) = \\ &= \frac{2}{\Delta t^{n+1}(\Delta t^{n} + \Delta t^{n+1})}[b - c_1 d_1 - c_2 d_2 - \ldots - c_N d_N - \Delta t^{n+1}(c_1 v_1^{n+1/2} + c_2 v_2^{n+1/2} + \ldots + c_N v_N^{n+1/2})] \end{aligned} \tag{31}$$

Finally, the Lagrange multiplier is given by:

$$\lambda = \frac{S_1 - S_2}{S_3} \tag{32}$$

and then the reactions by:

$$r_1 = c_1\lambda \qquad r_2 = c_2\lambda \qquad \ldots \qquad r_N = c_N\lambda. \tag{33}$$

2.5 Decoupled treatment by penalty

Another possibility of treating hanging links in a decoupled way is to use a penalty formulation. This would consist in adding a penalty or “restoring” force (a spring) proportional to the deviation of the position (or of the velocity, or of both) of the hanging node with respect to the position (respectively, the velocity) that it should have with respect to its master nodes.

This is illustrated in Figure 3 in the simple 2D case of a hanging node with two masters.

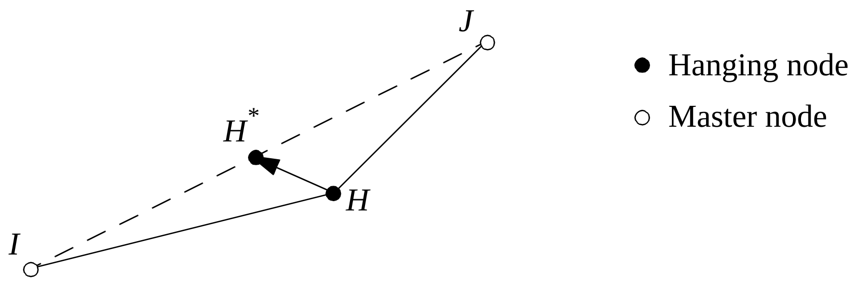

Figure 3 - Penalty for a hanging node in 2D

Let $\underline{d}_H^*$ and $\underline{v}_H^*$ be the displacement and the velocity of the hanging node resulting from interpolation of the master node values:

$$\begin{aligned} \underline{d}_H^* &= \sum_{K=1}^{N} c_K \underline{d}_K \\ \underline{v}_H^* &= \sum_{K=1}^{N} c_K \underline{v}_K \end{aligned} \tag{34}$$

and $\underline{d}_H$, $\underline{v}_H$ the actual current values of displacement and velocity. As said, the use of either displacements $\underline{d}$ or positions $\underline{x}$ is equivalent because, upon creation, the quantities of the (newly created) hanging nodes are interpolated from those of their master nodes and therefore satisfy the constraints.

A generic penalty force on the master node can be expressed as:

$$\underline{P}_H = c_d(\underline{d}_H^* - \underline{d}_H) + c_v(\underline{v}_H^* - \underline{v}_H) \tag{35}$$

where c_d and c_v are penalty coefficients relative to displacement (position) and velocity, respectively, which can either be chosen by the user or be tentatively determined automatically by the code. As usual, the vector equation (35) can be split into its (scalar) components along the global degrees of freedom.

Dimensional analysis shows that the c_d coefficient has dimensions of [N/m] in standard units, while c_v has dimensions of [N•s/m].

A tentative procedure for determining the coefficients, based upon the material properties of the elements to which the hanging and master nodes belong, could be as follows.

Let A represent the Young's modulus of the material, if we are considering a structure, or the bulk modulus of the material, if we a re considering a fluid. In both cases, the units are [Pa]. Let S be the area of the "face" defined by the master nodes [m^2]. In 2D plane cases this would simply be the distance between the (two) master nodes multiplied by one (the thickness), while in 2D axisymmetric this would be the distance between the two master nodes multiplied by the mean radius (half-sum of the master node radii). In 3D, for $N = 4$ (quadrilateral face) this would be the area of the quadrilateral, while for $N = 2$ (node hanging on a corner) the meaning of this quantity is not immediate: one could perhaps take the square of the corner's length.

Let us define a "characteristic length" L associated with the face, defined by:

$$L = \sqrt{S} \tag{36}$$

In the case of displacement-related penalty, one can obtain the (order of magnitude of the) restoring (penalty) force as follows (see Figure 4):

$$F = S\sigma = SA\varepsilon = SA\frac{d}{L} = LAd \tag{37}$$

where σ, ε are the elastic stress and strain induced in an imaginary cube of side L by the displacement d of one of its faces.

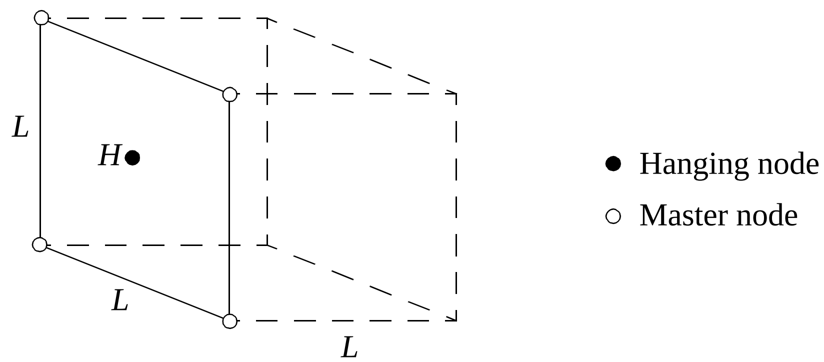

Figure 4 - Displacement-based penalty force in 3D (quadrilateral face)

2.6 Weak decoupled treatment

Finally, we consider a “weak” decoupled treatment of the hanging links. The proposed technique resembles the “weak” coupling algorithms used in EPX for Fluid-Structure Interaction (FSI), in particular the LINK DECO FLSR or LINK DECO FLSW algorithms (see [20]).

2.6.1 Case of a single hanging node

Let us first consider the simple case of a single hanging node H shown in Figure 1. Then, we proceed as follows:

1 Distribute the forces acting on the hanging node H and the mass of the hanging node onto its master nodes, I and J in this case. The linear shape functions N are used as coefficients. They have the property $\sum N = 1$. The forces to be distributed are both the (assembled) internal forces and the (assembled) external loads (e.g. gravity), if any, acting on H. The forces and the masses are (provisionally) added to those of the master nodes:

$$\begin{aligned} &\underline{F}_I^{\mathrm{Int}} \leftarrow \underline{F}_I^{\mathrm{Int}} + N_I \underline{F}_H^{\mathrm{Int}} \qquad \underline{F}_I^{\mathrm{Ext}} \leftarrow \underline{F}_I^{\mathrm{Ext}} + N_I \underline{F}_H^{\mathrm{Ext}} \\ &\underline{F}_J^{\mathrm{Int}} \leftarrow \underline{F}_J^{\mathrm{Int}} + N_J \underline{F}_H^{\mathrm{Int}} \qquad \underline{F}_J^{\mathrm{Ext}} \leftarrow \underline{F}_J^{\mathrm{Ext}} + N_J \underline{F}_H^{\mathrm{Ext}} \\ &\underline{m}_I \leftarrow \underline{m}_I + N_I \underline{m}_H \\ &\underline{m}_J \leftarrow \underline{m}_J + N_J \underline{m}_H \end{aligned} \tag{38}$$

2 Compute the accelerations of the master nodes:

$$\begin{aligned} \underline{a}_I &= (\underline{F}_I^{\mathrm{Ext}} - \underline{F}_I^{\mathrm{Int}}) / \underline{m}_I \\ \underline{a}_J &= (\underline{F}_J^{\mathrm{Ext}} - \underline{F}_J^{\mathrm{Int}}) / \underline{m}_J \end{aligned} \tag{39}$$

3 Obtain the acceleration of the hanging node by interpolation from the accelerations of the master nodes, again by using as coefficients the linear shape functions:

$$\underline{a}_H = N_I \underline{a}_I + N_J \underline{a}_J \tag{40}$$

Strictly speaking, the expressions (39) are formally incorrect because of the quotient between two vectors ($\underline{F}$ and $\underline{m}$) appearing on the right-hand side. However, the meaning should be clear: the expressions are valid for each component separately, so that alternatively one could use the notation m (scalar) for the mass, by tacitly assuming that this represents the translational mass of the node (the same in all directions) for the translational dofs, or the appropriate rotational component (different in general according to the axis considered) for the rotational dofs. In principle, this completes the weak coupling algorithm. However, it may be desirable (and useful) to compute the decoupled link forces ($\underline{F}^{\mathrm{Dec}}$), e.g. for visualization purposes. To this end, one might modify the procedure as follows. Let the superscript "free" denote quantities computed by neglecting the constraints due to hanging nodes. Then:

1 Compute the "free" accelerations of all nodes, i.e. the accelerations obtained by neglecting the constraints due to hanging nodes:

$$\begin{aligned} \underline{a}_I^{\text{free}} &= (\underline{F}_I^{\text{Ext}} - \underline{F}_I^{\text{Int}})^{\text{free}} / \underline{m}_I^{\text{free}} \\ \underline{a}_J^{\text{free}} &= (\underline{F}_J^{\text{Ext}} - \underline{F}_J^{\text{Int}})^{\text{free}} / \underline{m}_J^{\text{free}} \\ \underline{a}_H^{\text{free}} &= (\underline{F}_H^{\text{Ext}} - \underline{F}_H^{\text{Int}})^{\text{free}} / \underline{m}_H^{\text{free}} \end{aligned} \tag{41}$$

2 Distribute the forces and the masses of the hanging node onto the master nodes:

$$\begin{aligned} \underline{F}_I^{\text{Int}} &= \underline{F}_I^{\text{Int,free}} + N_I \underline{F}_H^{\text{Int,free}} \qquad \underline{F}_I^{\text{Ext}} = \underline{F}_I^{\text{Ext,free}} + N_I \underline{F}_H^{\text{Ext,free}} \\ \underline{F}_J^{\text{Int}} &= \underline{F}_J^{\text{Int,free}} + N_J \underline{F}_H^{\text{Int,free}} \qquad \underline{F}_J^{\text{Ext}} = \underline{F}_J^{\text{Ext,free}} + N_J \underline{F}_H^{\text{Ext,free}} \\ \underline{m}_I &= \underline{m}_I^{\text{free}} + N_I \underline{m}_H^{\text{free}} \\ \underline{m}_J &= \underline{m}_J^{\text{free}} + N_J \underline{m}_H^{\text{free}} \end{aligned} \tag{42}$$

3 Compute the "true" accelerations of the master nodes:

$$\begin{aligned} \underline{a}_I &= (\underline{F}_I^{\text{Ext}} - \underline{F}_I^{\text{Int}}) / \underline{m}_I \\ \underline{a}_J &= (\underline{F}_J^{\text{Ext}} - \underline{F}_J^{\text{Int}}) / \underline{m}_J \end{aligned} \tag{43}$$

4 Interpolate the "true" acceleration of the hanging node from the accelerations of the master nodes:

$$\underline{a}_H = N_I \underline{a}_I + N_J \underline{a}_J \tag{44}$$

5 Compute the decoupled link forces due to hanging constraints, both on the master nodes and on the hanging node:

$$\begin{aligned} \underline{F}_I^{\text{Dec}} &= (\underline{a}_I - \underline{a}_I^{\text{free}}) \underline{m}_I^{\text{free}} \\ \underline{F}_J^{\text{Dec}} &= (\underline{a}_J - \underline{a}_J^{\text{free}}) \underline{m}_J^{\text{free}} \\ \underline{F}_H^{\text{Dec}} &= (\underline{a}_H - \underline{a}_H^{\text{free}}) \underline{m}_H^{\text{free}} \end{aligned} \tag{45}$$

The relations (45) are self-evident. However, they can also be explained by reasoning as follows. If the generic node K (master or hanging) would be uncoupled (free) its acceleration would be:

$$\underline{a}_K^{\text{free}} = (\underline{F}_K^{\text{Ext}} - \underline{F}_K^{\text{Int}})^{\text{free}} / \underline{m}_K^{\text{free}} \tag{46}$$

But, due to the hanging constraints, the node is subjected to an additional force $\underline{F}_K^{\text{Dec}}$ (treated here as an external force, hence the plus sign below), so that its true acceleration is:

$$\underline{a}_K = (\underline{F}_K^{\text{Ext,free}} - \underline{F}_K^{\text{Int,free}} + \underline{F}_K^{\text{Dec}}) / \underline{m}_K^{\text{free}} \tag{47}$$

In other words, $\underline{F}_K^{\text{Dec}}$ is the force which transforms the acceleration of node K from its "free" (uncoupled) value $\underline{a}_K^{\text{free}}$ into its "true" value $\underline{a}_K$, by taking as mass of the node its "free" mass $\underline{m}_K^{\text{free}}$.

The true value of the acceleration $\underline{a}_K$ is supposed to be known at this point of the procedure, and is given by (43) if K is a master node, or by (44) if K is a hanging node.

The expression (47) can be re-written as:

$$\underline{a}_K = \frac{(\underline{F}_K^{\text{Ext,free}} - \underline{F}_K^{\text{Int,free}})}{\underline{m}_K^{\text{free}}} + \frac{\underline{F}_K^{\text{Dec}}}{\underline{m}_K^{\text{free}}} \tag{48}$$

and by using the expression (41) of the free acceleration:

$$\underline{a}_K = \underline{a}_K^{\text{free}} + \frac{\underline{F}_K^{\text{Dec}}}{\underline{m}_K^{\text{free}}} \tag{49}$$

From this, we obtain the expression (45) of the decoupled link forces due to hanging constraints:

$$\underline{F}_K^{\text{Dec}} = (\underline{a}_K - \underline{a}_K^{\text{free}})\underline{m}_K^{\text{free}} \tag{50}$$

Note that, since the decoupled link forces represent "internal" constraints, their algebraic sum must always vanish:

$$\sum_K \underline{F}_K^{\text{Dec}} \equiv \underline{0} \tag{51}$$

2.6.2 Case of two contiguous hanging nodes

Let us now consider a slightly more complex case, in which two "contiguous" hanging nodes H_1 and H_2 are present, as shown in Figure 2. The two hanging nodes are said to be contiguous because they share a common master node, i.e. node J in this example.

By proceeding similarly to the previous case of a single hanging node, we do the following calculations:

1 Compute the "free" accelerations of all nodes, i.e. the accelerations obtained by neglecting the constraints due to hanging nodes (L indicates both master and hanging nodes):

$$\underline{a}_L^{\text{free}} = (\underline{F}_L^{\text{Ext}} - \underline{F}_L^{\text{Int}})^{\text{free}} / \underline{m}_L^{\text{free}} \qquad L = I, J, K, H_1, H_2 \tag{52}$$

2 Distribute the forces and the masses of each hanging node onto its own master nodes:

$$
\begin{aligned}
\underline{F}_I^{\mathrm{Int}} &= \underline{F}_I^{\mathrm{Int,free}} + N_{1I}\underline{F}_{H_1}^{\mathrm{Int,free}} & \underline{F}_I^{\mathrm{Ext}} &= \underline{F}_I^{\mathrm{Ext,free}} + N_{1I}\underline{F}_{H_1}^{\mathrm{Ext,free}} \\
\underline{F}_J^{\mathrm{Int}} &= \underline{F}_J^{\mathrm{Int,free}} + N_{1J}\underline{F}_{H_1}^{\mathrm{Int,free}} + N_{2J}\underline{F}_{H_2}^{\mathrm{Int,free}} & \underline{F}_J^{\mathrm{Ext}} &= \underline{F}_J^{\mathrm{Ext,free}} + N_{1J}\underline{F}_{H_1}^{\mathrm{Ext,free}} + N_{2J}\underline{F}_{H_2}^{\mathrm{Ext,free}} \\
\underline{F}_K^{\mathrm{Int}} &= \underline{F}_K^{\mathrm{Int,free}} + N_{2K}\underline{F}_{H_2}^{\mathrm{Int,free}} & \underline{F}_K^{\mathrm{Ext}} &= \underline{F}_K^{\mathrm{Ext,free}} + N_{2K}\underline{F}_{H_2}^{\mathrm{Ext,free}} \\
\underline{m}_I &= \underline{m}_I^{\mathrm{free}} + N_{1I}\underline{m}_{H_1}^{\mathrm{free}} \\
\underline{m}_J &= \underline{m}_J^{\mathrm{free}} + N_{1J}\underline{m}_{H_1}^{\mathrm{free}} + N_{2J}\underline{m}_{H_2}^{\mathrm{free}} \\
\underline{m}_K &= \underline{m}_K^{\mathrm{free}} + N_{2K}\underline{m}_{H_2}^{\mathrm{free}}
\end{aligned}
\tag{53}
$$

3 Compute the “true” accelerations of the master nodes (indicated by M):

$$
\underline{a}_M = (\underline{F}_M^{\mathrm{Ext}} - \underline{F}_M^{\mathrm{Int}})/\underline{m}_M \qquad M = I, J, K \tag{54}
$$

4 Interpolate the “true” accelerations of the hanging nodes from the accelerations of the corresponding master nodes:

$$
\begin{aligned}
\underline{a}_{H_1} &= N_{1I}\underline{a}_I + N_{1J}\underline{a}_J \\
\underline{a}_{H_2} &= N_{2J}\underline{a}_J + N_{2K}\underline{a}_K
\end{aligned}
\tag{55}
$$

5 Compute the decoupled link forces due to hanging constraints, both on the master nodes and on the hanging nodes:

$$
\underline{F}_L^{\mathrm{Dec}} = (\underline{a}_L - \underline{a}_L^{\mathrm{free}})\underline{m}_L^{\mathrm{free}} \qquad L = I, J, K, H_1, H_2 \tag{56}
$$

Again, since the decoupled link forces represent “internal” constraints, their algebraic sum must vanish.

From the above description one sees that the treatment of two (or more) contiguous hanging nodes does not require any conceptual modification with respect to the case of a single hanging node. This is because in this example and in the previous one the local degree of mesh non-conformity is (at most) one. In other words, the difference in refinement level between any couple of neighboring (or pseudo-neighboring) elements is at most one. This condition is satisfied in EPX if one sets option OPTI ADAP RCON, but it is not guaranteed, in general, if the option is not set.

2.6.3 General case of multiple hanging nodes at different levels

Finally, let us consider the most general case, i.e. the presence of multiple hanging nodes at different levels of the mesh adaptation tree as illustrated in Figure 5 below.

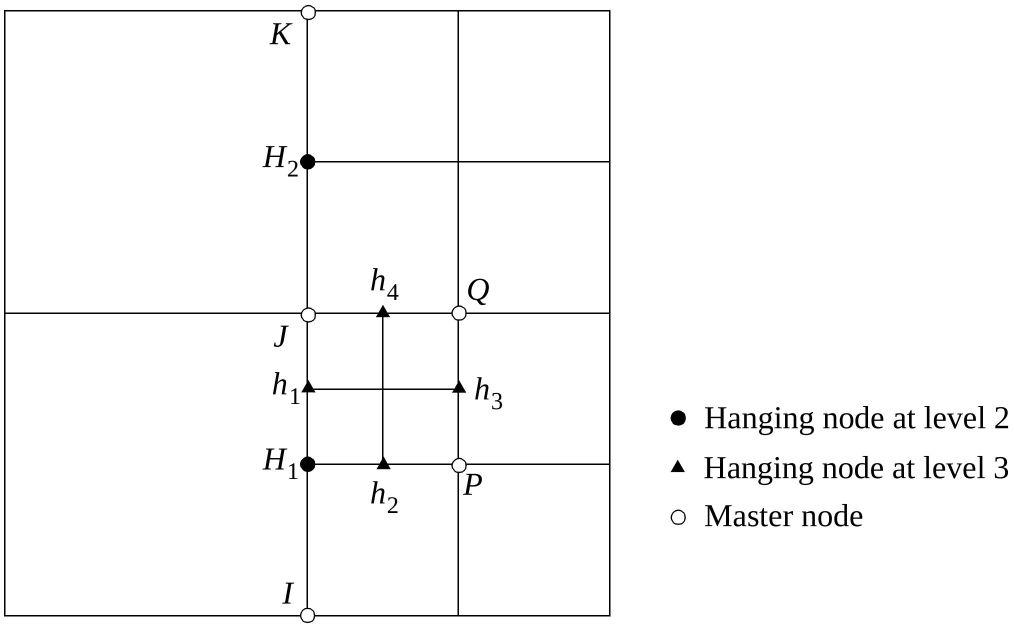

Figure 5 - Example of several hanging nodes at various levels in 2D

For example, the node h_1 belongs to the “third” level of the adaptivity tree and hangs upon nodes J and H_1 (which in turn hangs upon I and J). The other hanging nodes at level 3 are h_2 (on H_1 and P), h_3 (on P and Q) and h_4 (on Q and J). It is recalled that, by convention, level 1 of the adaptivity tree is the base mesh.

We see therefore that, in the data structure currently implemented in EPX, the masters of a hanging node may themselves hang upon other nodes. This is not a problem if a coupled solution of the hanging constraints is performed, as is done in EPX by default by means of the (coupled) method of Lagrange multipliers.

However, when a decoupled solution of the hanging constraints is sought, some problem might arise unless the decoupled solution procedure is formulated with care.

The procedure proposed above is generalized to the case of arbitrary-level hanging constraints as follows (by following the example of Figure 5).

1 Compute the “free” accelerations of all nodes, i.e. the accelerations obtained by neglecting the constraints due to hanging nodes (L indicates both master and hanging nodes, at any level):

$$\underline{a}_L^{\text{free}} = (\underline{F}_L^{\text{Ext}} - \underline{F}_L^{\text{Int}})^{\text{free}} / \underline{m}_L^{\text{free}} \qquad L = I, J, K, P, Q, H_1, H_2, h_1, h_2, h_3, h_4 \tag{57}$$

2 Initialize the forces. By using the symbol F to denote either F^{Int} or F^{Ext} for brevity:

$$\underline{F}_L \leftarrow \underline{F}_L^{\mathrm{free}} \qquad L = I, J, K, P, Q, H_1, H_2, h_1, h_2, h_3, h_4 \tag{58}$$

3 Distribute the forces and the masses of each hanging node onto its own master nodes, <u>starting from the hanging nodes at the deepest level</u> and proceeding "upward" the adaptivity tree. In the example, at the third level of the adaptivity tree we have hanging nodes h_1, h_2, h_3 and h_4, so that (by noting that all shape functions N equal $1/2$ in 2D):

$$\begin{aligned}
\underline{F}_J &\leftarrow \underline{F}_J + 0.5\underline{F}_{h_1} & \underline{m}_J &\leftarrow \underline{m}_J + 0.5\underline{m}_{h_1}\\
\underline{F}_{H_1} &\leftarrow \underline{F}_{H_1} + 0.5\underline{F}_{h_1} & \underline{m}_{H_1} &\leftarrow \underline{m}_{H_1} + 0.5\underline{m}_{h_1}\\
\underline{F}_{H_1} &\leftarrow \underline{F}_{H_1} + 0.5\underline{F}_{h_2} & \underline{m}_{H_1} &\leftarrow \underline{m}_{H_1} + 0.5\underline{m}_{h_2}\\
\underline{F}_P &\leftarrow \underline{F}_P + 0.5\underline{F}_{h_2} & \underline{m}_P &\leftarrow \underline{m}_P + 0.5\underline{m}_{h_2}\\
\underline{F}_P &\leftarrow \underline{F}_P + 0.5\underline{F}_{h_3} & \underline{m}_P &\leftarrow \underline{m}_P + 0.5\underline{m}_{h_3}\\
\underline{F}_Q &\leftarrow \underline{F}_Q + 0.5\underline{F}_{h_3} & \underline{m}_Q &\leftarrow \underline{m}_Q + 0.5\underline{m}_{h_3}\\
\underline{F}_Q &\leftarrow \underline{F}_Q + 0.5\underline{F}_{h_4} & \underline{m}_Q &\leftarrow \underline{m}_Q + 0.5\underline{m}_{h_4}\\
\underline{F}_J &\leftarrow \underline{F}_J + 0.5\underline{F}_{h_4} & \underline{m}_J &\leftarrow \underline{m}_J + 0.5\underline{m}_{h_4}
\end{aligned} \tag{59}$$

Note that the order in which operations (59) are performed is irrelevant. At the second level, we have the two hanging nodes H_1 and H_2, so that (again, the order is irrelevant):

$$\begin{aligned}
\underline{F}_I &\leftarrow \underline{F}_I + 0.5\underline{F}_{H_1} & \underline{m}_I &\leftarrow \underline{m}_I + 0.5\underline{m}_{H_1}\\
\underline{F}_J &\leftarrow \underline{F}_J + 0.5\underline{F}_{H_1} & \underline{m}_J &\leftarrow \underline{m}_J + 0.5\underline{m}_{H_1}\\
\underline{F}_J &\leftarrow \underline{F}_J + 0.5\underline{F}_{H_2} & \underline{m}_J &\leftarrow \underline{m}_J + 0.5\underline{m}_{H_2}\\
\underline{F}_K &\leftarrow \underline{F}_K + 0.5\underline{F}_{H_2} & \underline{m}_K &\leftarrow \underline{m}_K + 0.5\underline{m}_{H_2}
\end{aligned} \tag{60}$$

4 Compute the "true" accelerations of the "pure" master nodes (indicated by M), i.e. of those master nodes (at any level of the adaptivity tree) which do not hang upon other nodes. In this example, all such nodes happen to be at level 1 (base nodes), but this is not true in general:

$$\underline{a}_M = (\underline{F}_M^{\mathrm{Ext}} - \underline{F}_M^{\mathrm{Int}})/\underline{m}_M \qquad M = I, J, K, P, Q \tag{61}$$

5 Interpolate the “true” accelerations of the hanging nodes from the accelerations of the corresponding master nodes, starting from level 2 and proceeding “downward” the adaptivity tree, i.e. in the opposite sense with respect to the distribution of forces at point 3 of the procedure. At level 2 we have:

$$\begin{aligned} \underline{a}_{H_1} &= 0.5\underline{a}_I + 0.5\underline{a}_J \\ \underline{a}_{H_2} &= 0.5\underline{a}_J + 0.5\underline{a}_K \end{aligned} \tag{62}$$

Then, at level 3 we have:

$$\begin{aligned} \underline{a}_{h_1} &= 0.5\underline{a}_J + 0.5\underline{a}_{H_1} \\ \underline{a}_{h_2} &= 0.5\underline{a}_{H_1} + 0.5\underline{a}_P \\ \underline{a}_{h_3} &= 0.5\underline{a}_P + 0.5\underline{a}_Q \\ \underline{a}_{h_4} &= 0.5\underline{a}_Q + 0.5\underline{a}_J \end{aligned} \tag{63}$$

6 Compute the decoupled link forces due to hanging constraints, both on the master nodes and on the hanging nodes (at any level):

$$\underline{F}_L^{\mathrm{Dec}} = (\underline{a}_L - \underline{a}_L^{\mathrm{free}})\underline{m}_L^{\mathrm{free}} \qquad L = I, J, K, P, Q, H_1, H_2, h_1, h_2, h_3, h_4 \tag{64}$$

As usual, since the decoupled link forces represent “internal” constraints, their algebraic sum must always vanish.

2.7 Implementation notes

It is recalled that the standard (fully coupled) treatment of hanging nodes by Lagrange multipliers is implemented in routine LINK_HANGING_ADAP of module M_ADAPTIVITY_LINKS. This routine is called by CALCUL (or TLOOPP). It loops over all (active) nodes and, for each hanging node, it adds the corresponding constraint(s) to the global system of links.

The newly implemented decoupled treatments are contained in routines DECO_HANGING_ADAP, PENA_HANGING_ADAP and WEAK_HANGING_ADAP, which are also contained in module M_ADAPTIVITY_LINKS. The first routine uses the decoupled Lagrange multiplier method illustrated in Sections 2.3 (for velocity-based constraints) or 2.4 (for displacement-based constraints). It calls two new ancillary routines in the same module: SOLVE_SINGLE_HANG which solves a single hanging constraint based on velocities and SOLVE_SINGLE_HANG_DEPL which solves a single hanging constraint based on displacements.

The second routine uses the penalty approach illustrated in Section 2.5, but at the moment only the displacement-based penalty in 2D is implemented since preliminary numerical results are not encouraging (see Section 3).

The third routine uses the weak approach proposed in Section 2.6.

The decoupled-treatment routines are also called from CALCUL (or TLOOPP), but in the part dealing with decoupled constraints.

Some new input options are added (see logical page H.180 of the User's Manual [20]):

```
OPTI ADAP ... < $ PHAN CD cd <CV cv> ;
                  DHAN < $ DEPL ; VITE $ >
                  WHAN $ >
```

The `PHAN` keyword activates penalty-based hanging constraints as detailed in Section 2.5. The `CD` coefficient on displacements and (optionally) the `CV` coefficient on velocities (this one is zero by default) have to be specified.

The `DHAN` keyword activates decoupled Lagrange-multiplier based treatment of hanging constraints of Sections 2.3 and 2.4. The formulation is on displacements if the `DEPL` keyword (or nothing) is specified, while it is on velocities if the `VITE` keyword is specified.

The `WHAN` keyword activates weak decoupled treatment of hanging constraints of Section 2.6. The CALCUL (or TLOOPP) routines first compute the nodal accelerations by completely ignoring the constraints due to hanging nodes. These are the values indicated as "free" accelerations in Section 2.6.3. Next, they call M_ADAPTIVITY_LINKS::WEAK_HANGING_ADAP in order to compute the true accelerations and the decoupled forces (FDEC) for the nodes concerned.

In order to apply the procedure described in Section 2.6.3, an ordered list WHAN_NODES(:) of the concerned nodes is needed. The list must be re-built anew at each time step because in general the hanging nodes vary. It will be traversed in reverse order (from the deepest level of the adaptivity tree upward) at point 3 of the procedure (re-distribution of forces and masses), and in direct order (from the shallowest level downward) at point 5 of the procedure (interpolation of accelerations).

The list WHAN_NODES contains both the hanging and the master nodes organized as follows:

- First, all master nodes at level 1 (base nodes). Recall in fact that at level 1 there may be no hanging nodes.
- Then, all hanging and/or master nodes at level 2, if any.
- Then, all hanging and/or master nodes at level 3, if any.

- Etc., until the last level. Recall that at the last (deepest) level there may be no master nodes, but there can be hanging nodes.

At each level, the nodes may be listed in any order.

3. Numerical examples

We now present some numerical examples in order to check the models and procedures described in the previous Chapter.

3.1 Static adaptivity

We solve the problem shown in Figure 6. A square plate is clamped along its perimeter and loaded by a uniform and constant pressure of 10 bar. The base mesh of the plate consists of 10 by 10 shell elements of type Q4GS. The central part of the plate mesh is initially refined to level 2 and then kept constant throughout the transient calculation (“static” adaptivity). This produces 24 hanging nodes, as shown in Figure 6.

The simulations performed are summarized in Table 1.

Case	Fluid	Structure	FSI	Notes
Q4GS11	—	Q4GS	—	Reference solution (no option)
Q4GS12	—	Q4GS	—	OPTI ADAP DHAN VITE
Q4GS13	—	Q4GS	—	OPTI ADAP DHAN
Q4GS14	—	Q4GS	—	INIT ADAP SPLI LEVE 3, reference
Q4GS16	—	Q4GS	—	Idem 14 plus DHAN
Q4GS17	—	Q4GS	—	Idem 11 plus WHAN
Q4GS18	—	Q4GS	—	Idem 14 plus WHAN

Table 1 - Test cases with “static” adaptivity

Q4GS11

This solution uses no particular options. Therefore the classical fully-coupled Lagrange multipliers method is used to constrain the hanging nodes. By inspecting the .LKS output file we see that there are 240 links of type BLOQ along the border (6 constraints for each one of the 40 blocked nodes) and 144 (coupled) links of type HANG (6 constraints for each one of the 24 hanging nodes).

Since the mesh does not vary in this particular case, all these links are *de facto* permanent ones.

This can be considered as the reference solution of the problem. Figure 7 shows the displacement of the central point of the plate.

Q4GS12

This test is identical to Q4GS11 but we add the option `OPTI ADAP DHAN VITE` in order to activate decoupled Lagrange multiplier treatment of hanging nodes based on velocities. The solution becomes unstable at step 342, at a time of 21.4 ms.

Q4GS13

This solution is identical to Q4GS11 but we add the option `OPTI ADAP DHAN` in order to activate decoupled Lagrange multiplier treatment of hanging nodes based on displacements. The solution is stable and reaches the final time of 60 ms in 751 time steps.

The solution in terms of central displacement is compared in Figure 8 with the reference, showing excellent agreement.

Q4GS14

This solution is identical to Q4GS11 but the plate mesh is adapted up to level 3 at the initial time, in order to check whether the level of refinement has an influence on results. The OPTI ADAP RCON option is activated to obtain a smooth mesh size transition. This results in the mesh shown in Figure 9, which contains 80 hanging nodes. The solution is shown in Figure 10.

Q4GS16

This solution is identical to Q4GS14 but we add the option `OPTI ADAP DHAN` in order to activate decoupled Lagrange multiplier treatment of hanging nodes based on displacements. The solution is stable and reaches the final time of 60 ms in 1501 time steps.

The solution in terms of central displacement is compared in Figure 11 with the reference, showing excellent agreement.

It seems therefore that one can conclude that, at least in the case of “static” (constant in time) mesh adaptivity, the use of displacement-based uncoupled Lagrange multiplier constraints on hanging nodes gives good results.

Q4GS17

This solution is identical to Q4GS11 but we add the option `OPTI ADAP WHAN` in order to activate the weak decoupled treatment of hanging nodes as described in Section 2.6.

Results are shown in Figure 12 and are in excellent agreement with the reference solution Q4GS11.

Q4GS18

This solution is identical to Q4GS14 (level 3 refined mesh) but we add the option `OPTI ADAP WHAN` in order to activate the weak decoupled treatment of hanging nodes as described in Section 2.6.

Results are shown in Figure 13 and are in excellent agreement with the reference solution Q4GS14.

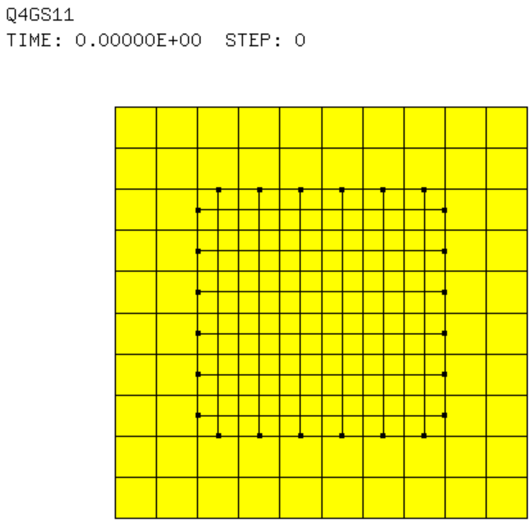

Figure 6 - Adapted mesh in case Q4GS11

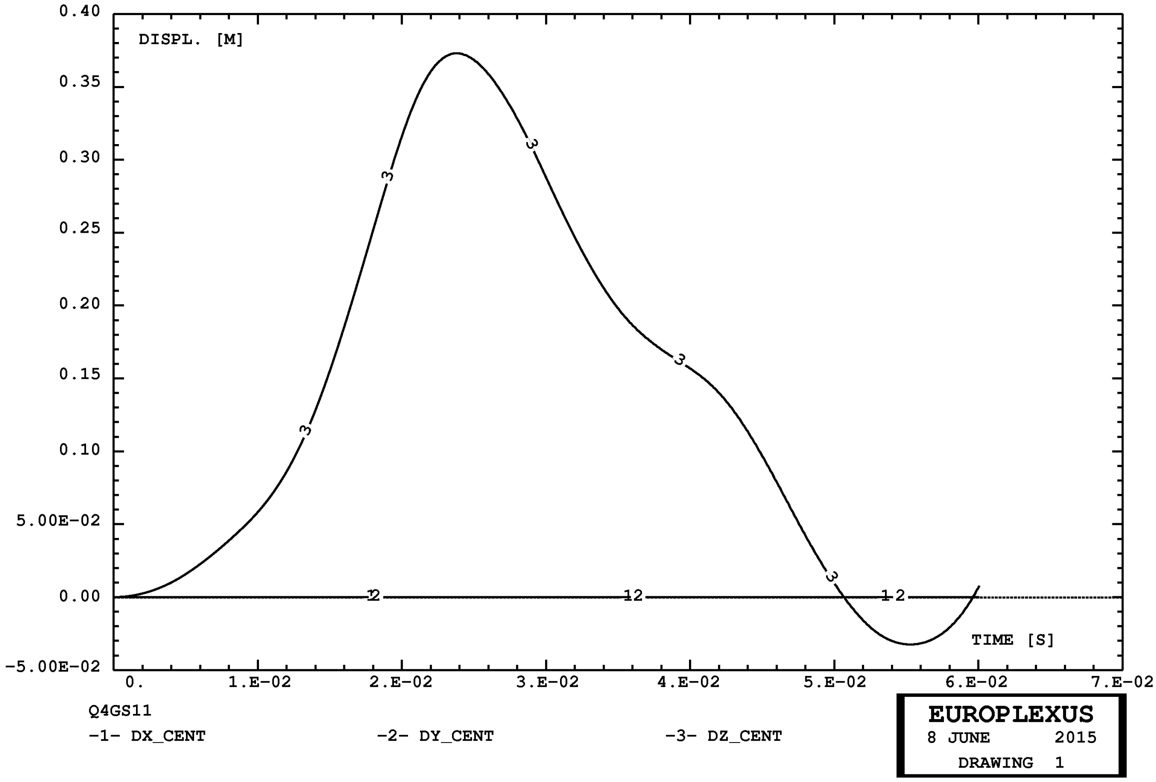

Figure 7 - Central displacement of the plate in case Q4GS11

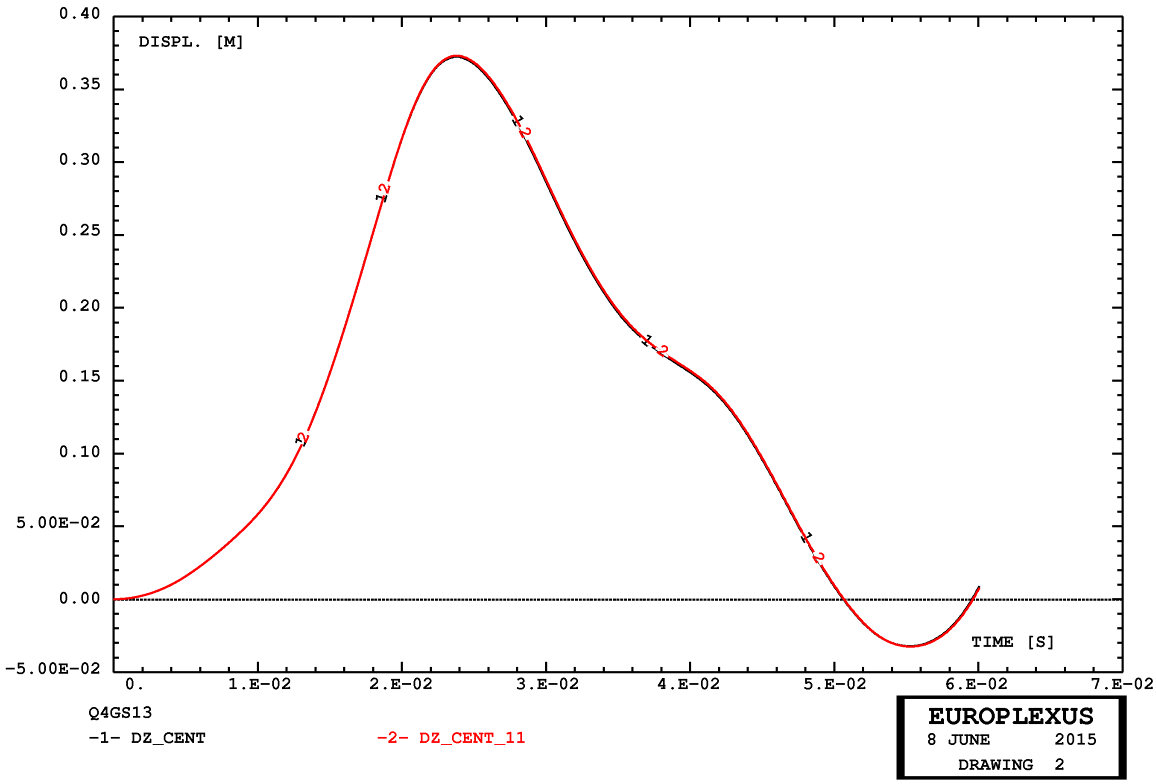

Figure 8 - Comparison of solutions in cases Q4GS11 and Q4GS13

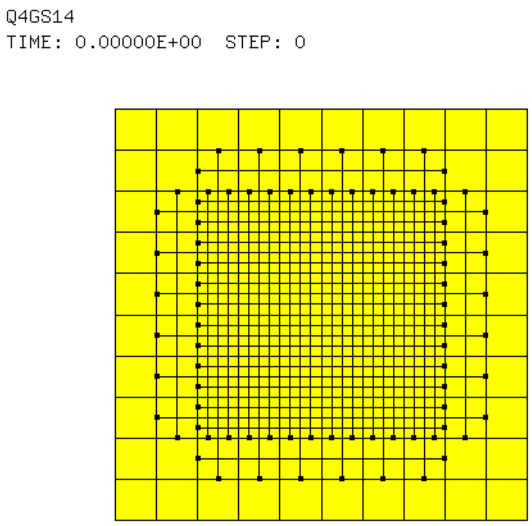

Figure 9 - Adapted mesh in case Q4GS14

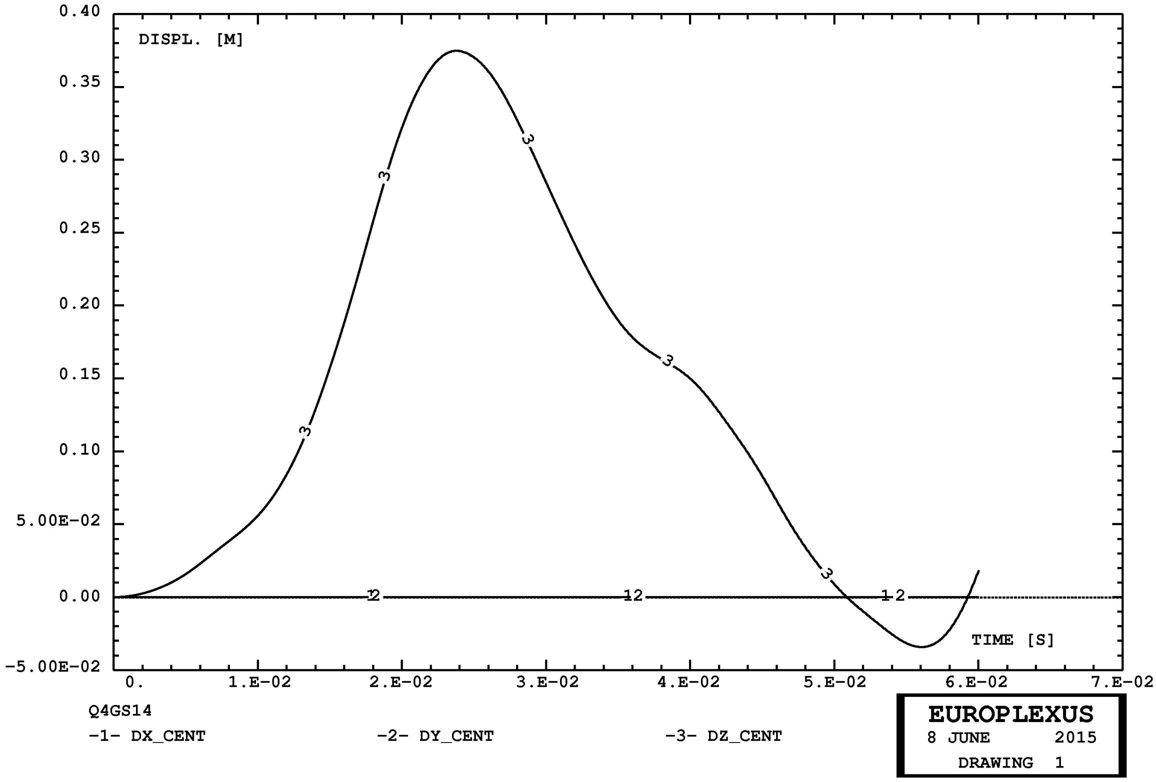

Figure 10 - Central displacement of the plate in case Q4GS14

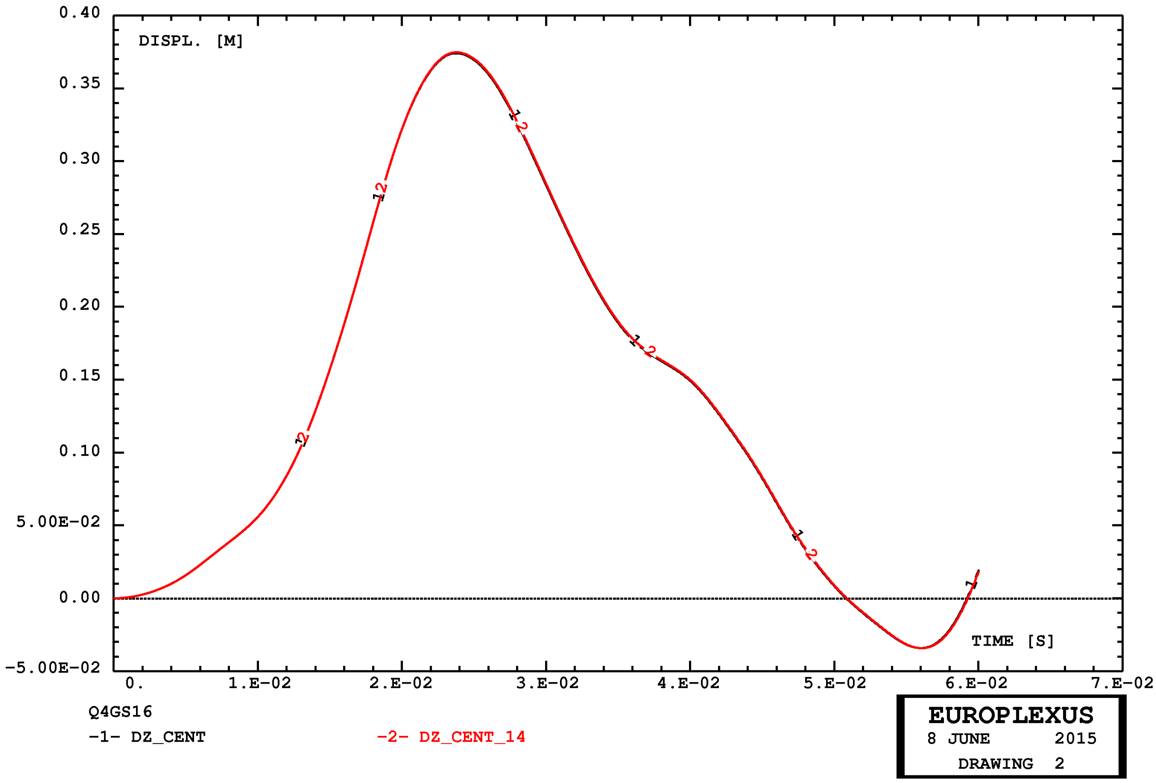

Figure 11 - Comparison of solutions in cases Q4GS14 and Q4GS16

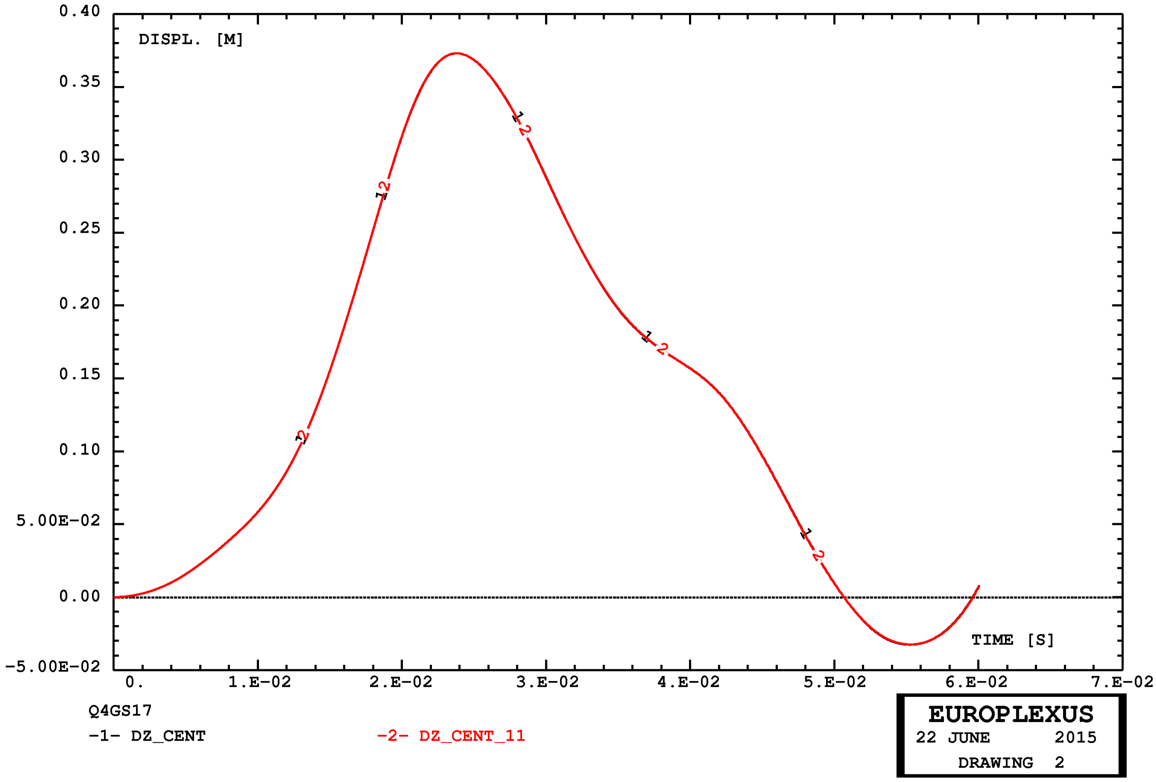

Figure 12 - Comparison of solutions in cases Q4GS11 and Q4GS17

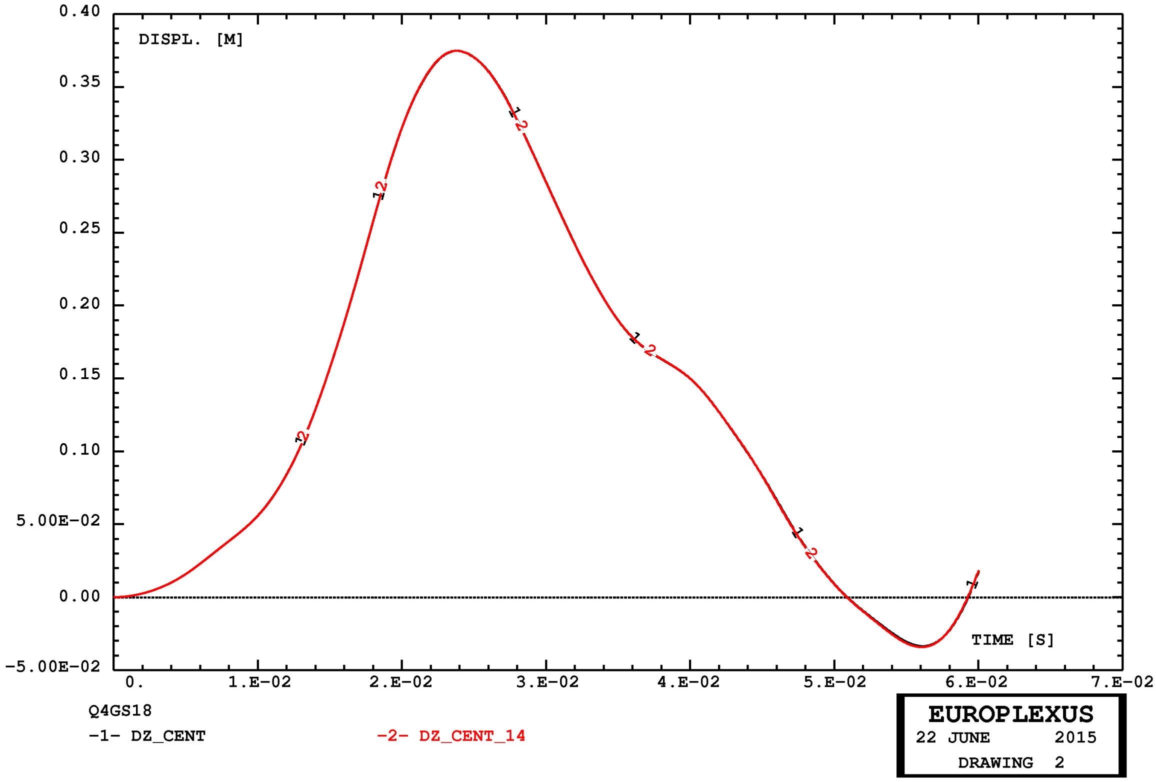

Figure 13 - Comparison of solutions in cases Q4GS14 and Q4GS18

3.2 Dynamic adaptivity

We solve the problem shown in Figure 14. A rectangular elastic bar is loaded at the left extremity by a uniform and constant pressure of 10 bar. The base mesh of the bar consists of 10 quadrilateral continuum elements of type Q41L. The bar mesh is adapted by the WAVE directive. At the initial time, this produces the mesh shown in Figure 14, containing 7 hanging nodes (highlighted in the Figure). However, in this case the mesh adaptation is dynamic (following the imposed wave) and both the position and the number of hanging nodes continuously changes in time.

The simulations performed are summarized in Table 1.

Case	Fluid	Structure	FSI	Notes
TWAD12	—	Q41L	—	Reference solution (no option)
TWAD62	—	Q41L	—	OPTI ADAP PHAN CD 2.E11
TWAD63	—	Q41L	—	OPTI ADAP PHAN CD 3.E10
TWAD64	—	Q41L	—	OPTI ADAP PHAN CD 3.E9
TWAD72	—	Q41L	—	OPTI ADAP DHAN VITE
TWAD82	—	Q41L	—	OPTI ADAP DHAN
TWAD92	—	Q41L	—	OPTI ADAP WHAN

Table 2 - Test cases with "static" adaptivity

TWAD12

This solution uses no particular options. Therefore the classical fully-coupled Lagrange multipliers method is used to constrain the hanging nodes. This can be considered as the reference solution of the problem.

Figure 15 shows the displacement of some points of the bar (left, middle and right points) versus time, while Figure 16 shows the corresponding velocities.

TWAD62

This solution is similar to TWAD12 but uses the OPTI ADAP PHAN option with CD 2.E11. This value corresponds to the Young's modulus of the elastic material in the bar.

The solution is unstable (strong oscillations) at step 21 and time 2 microseconds.

TWAD63

This solution is similar to TWAD62 but uses CD 3.E10. This value is roughly 1/10 of the elastic modulus in the material. The solution reaches the final time but the result is very bad, as can be seen in Figures 17 and 18.

TWAD64

This solution is similar to TWAD63 but the value of CD is further reduced to 3.E9. This value is roughly 1/100 of the elastic modulus in the material. The solution reaches the final time and the result is better than in the previous case, but still bad, as can be seen in Figures 19 and 20.

It seems therefore quite difficult to find an optimal value of the penalty coefficient(s). The next solutions will use the (decoupled) Lagrange multipliers method.

TWAD72

This solution is similar to TWAD12 but uses the option OPTI ADAP DHAN VITE, which activates velocity-based decoupled Lagrange multipliers method. The solution is shown in Figures 21 and 22. Although the solution in terms of displacements may seem acceptable, the velocity results are poor.

TWAD82

This solution is similar to TWAD12 but uses the option OPTI ADAP DHAN, which activates displacement-based decoupled Lagrange multipliers method. The solution is shown in Figures 23 and 24. Both displacements and velocities agree reasonably well with the reference solution, if one considers the very coarse mesh used.

TWAD92

This solution is similar to TWAD12 but uses the option OPTI ADAP WHAN, which activates the weak decoupled method proposed in Section 2.6. The solution is shown in Figures 25 and 26 and agrees very well with that of case TWAD12.

Figure 14 - Initially adapted mesh in case TWAD12

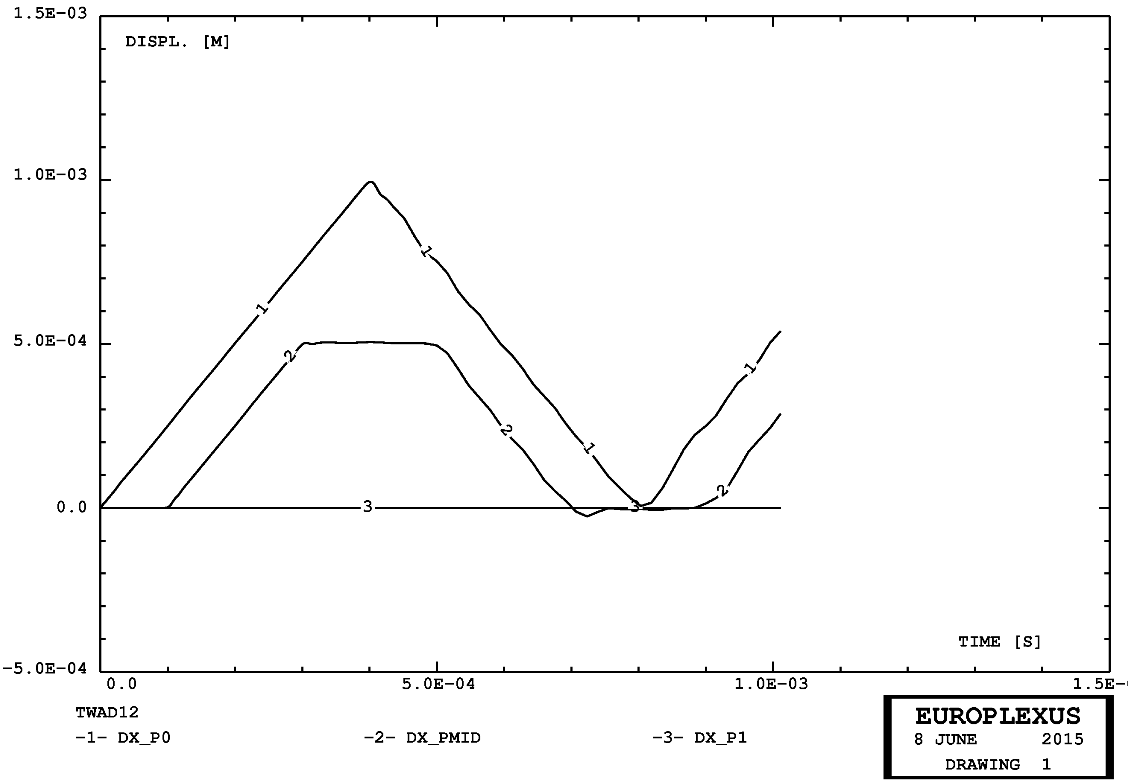

Figure 15 - Displacement of some points of the bar in case TWAD12

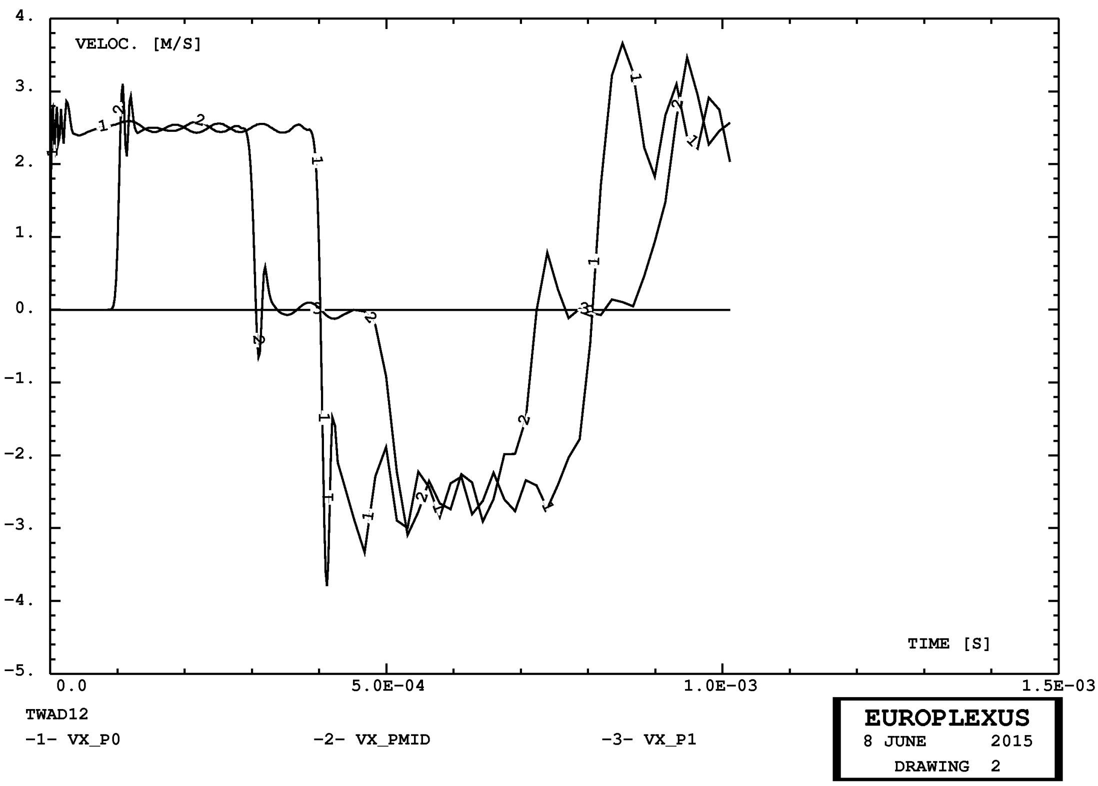

Figure 16 - Velocity of some points of the bar in case TWAD12

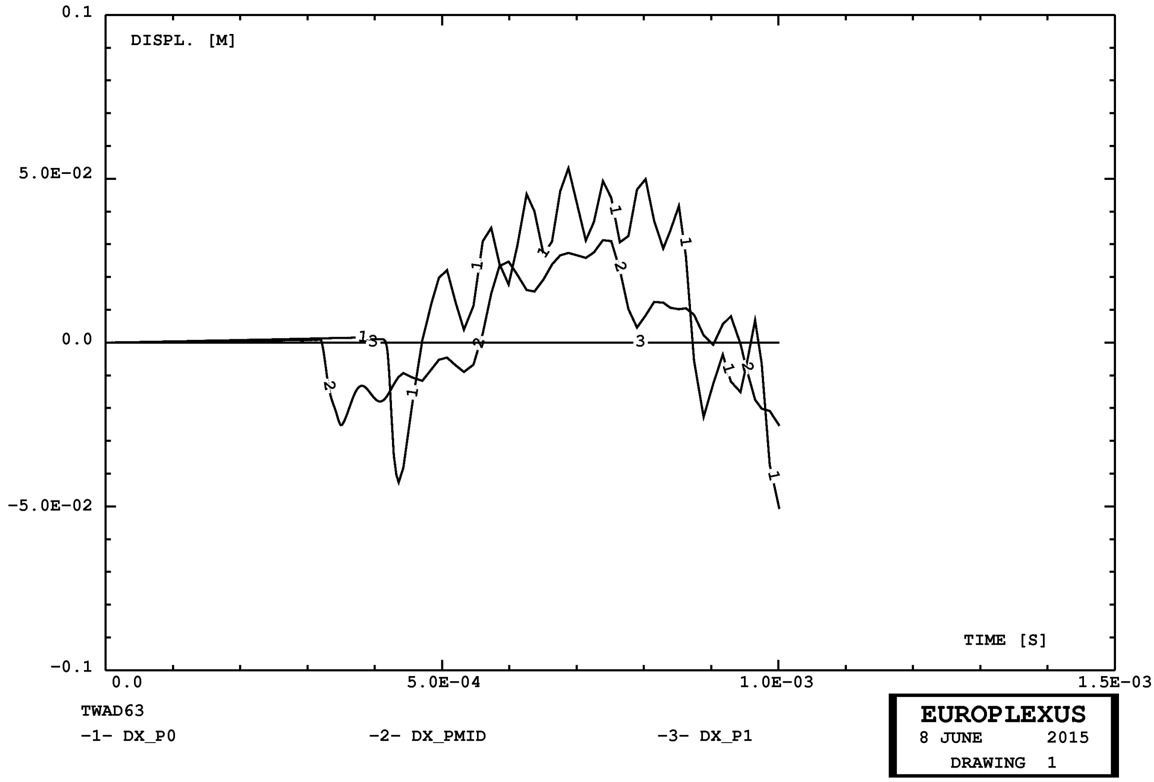

Figure 17 - Displacement of some points of the bar in case TWAD63

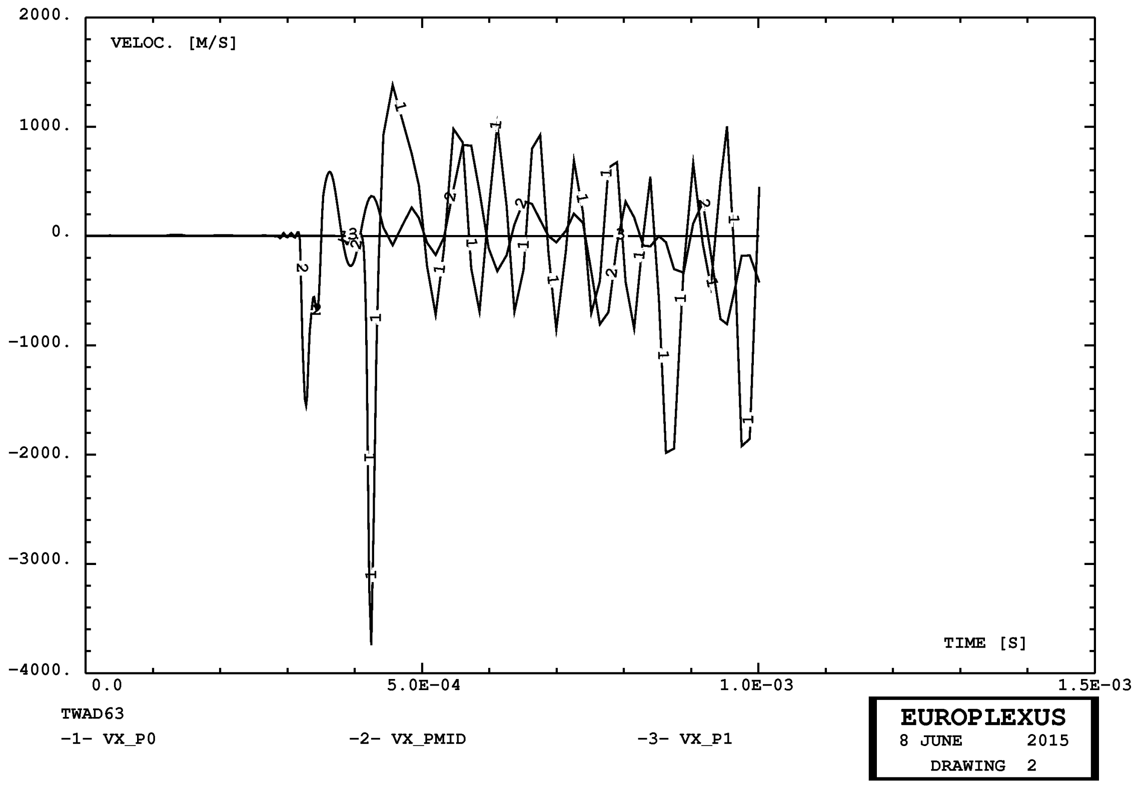

Figure 18 - Velocity of some points of the bar in case TWAD63

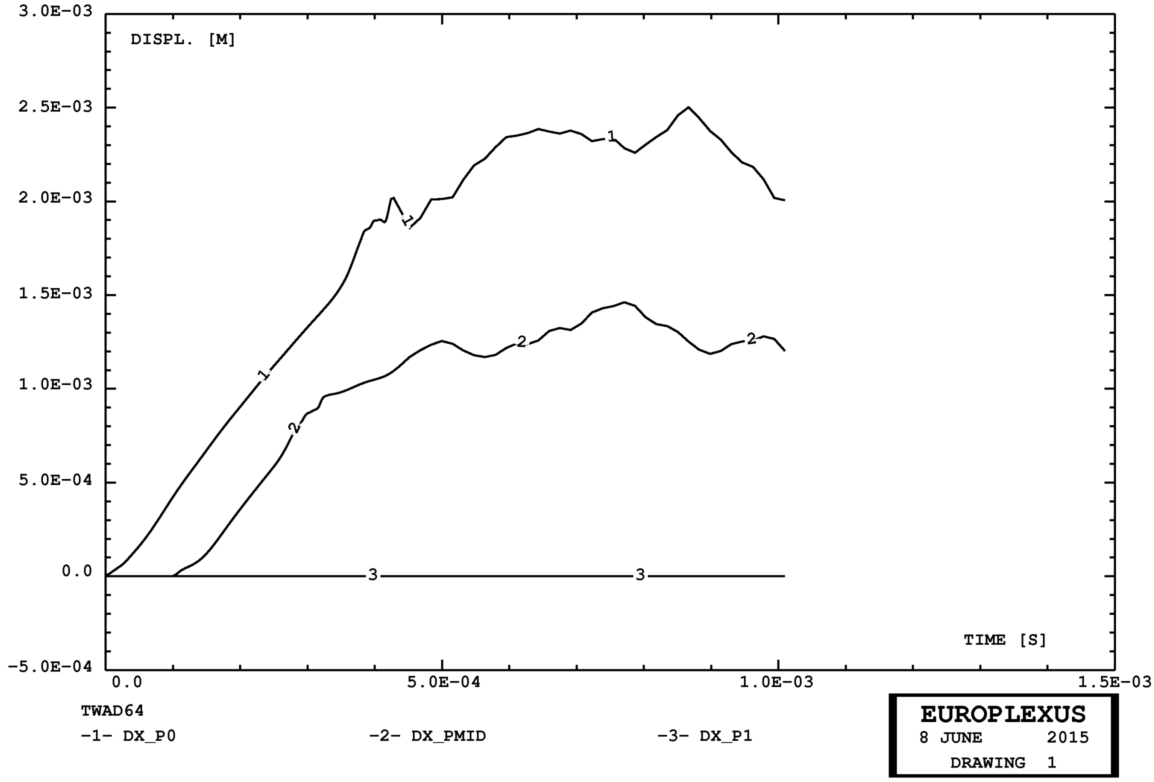

Figure 19 - Displacement of some points of the bar in case TWAD64

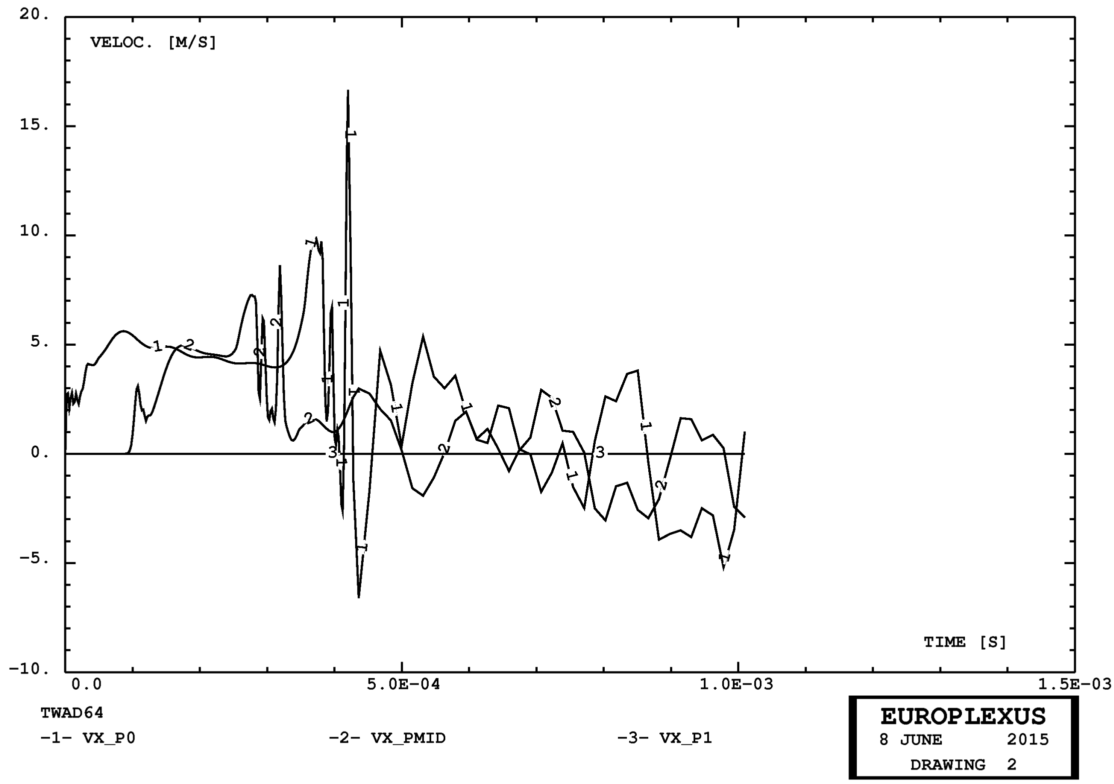

Figure 20 - Velocity of some points of the bar in case TWAD64

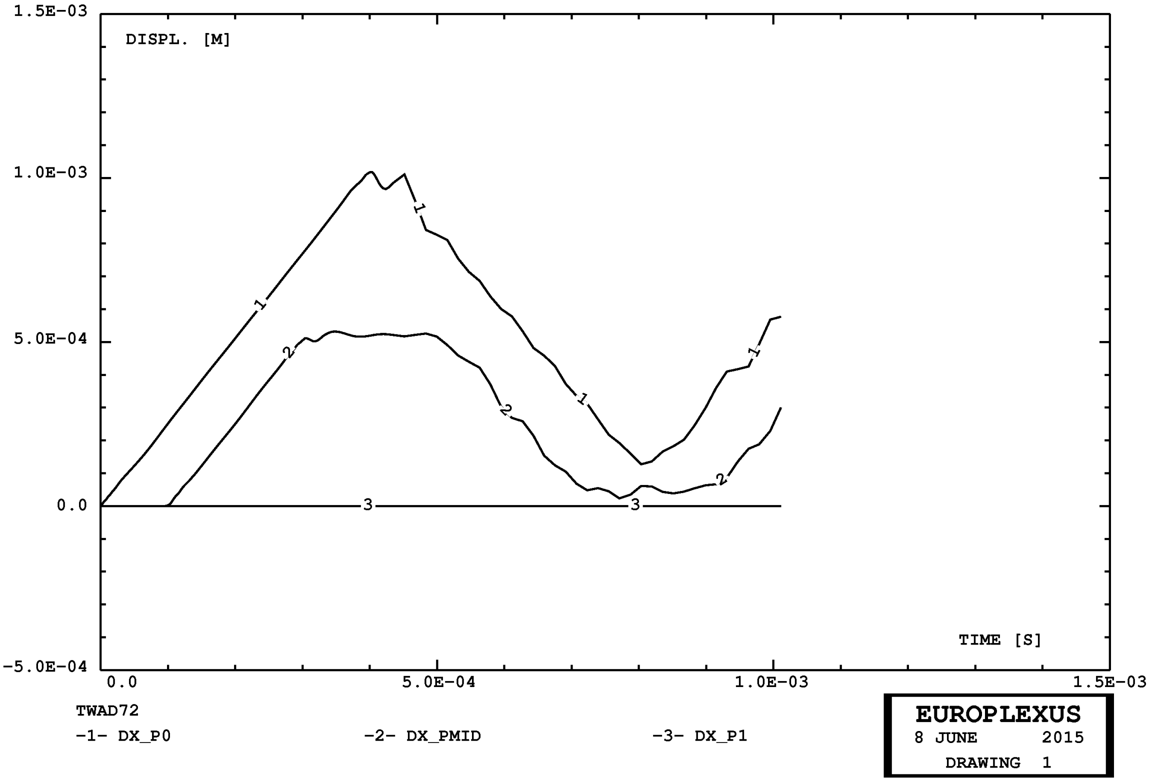

Figure 21 - Displacement of some points of the bar in case TWAD72

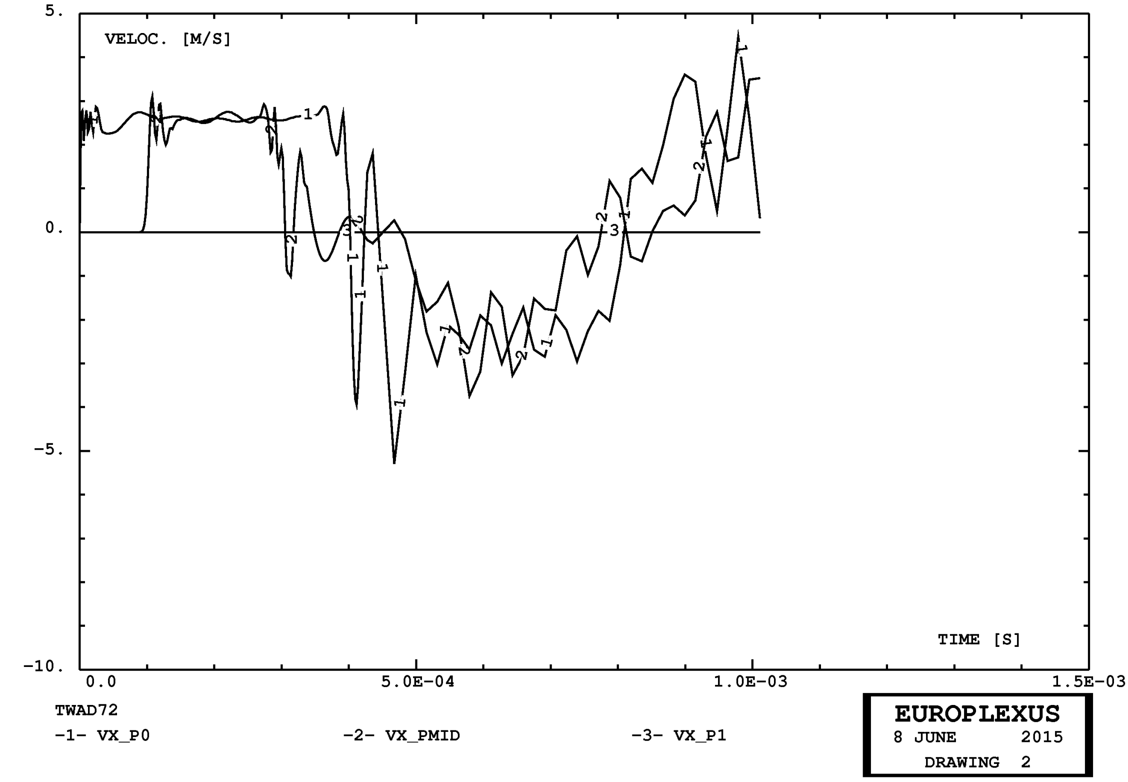

Figure 22 - Velocity of some points of the bar in case TWAD72

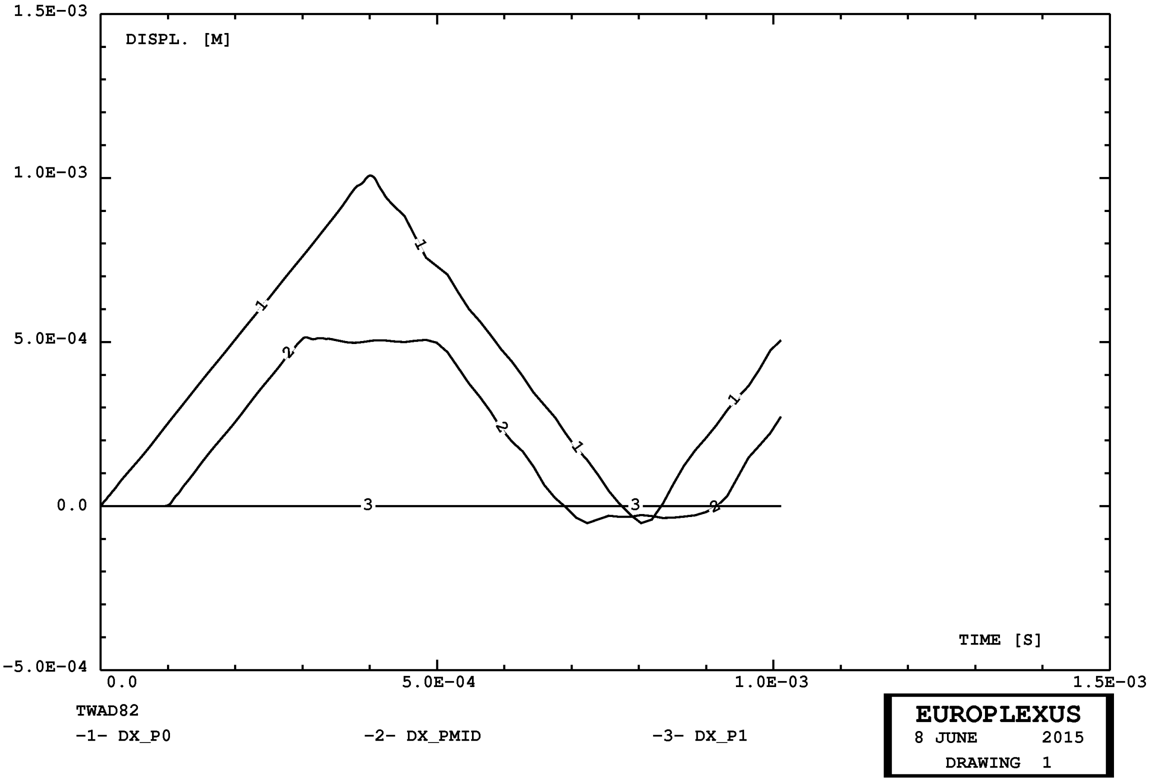

Figure 23 - Displacement of some points of the bar in case TWAD82

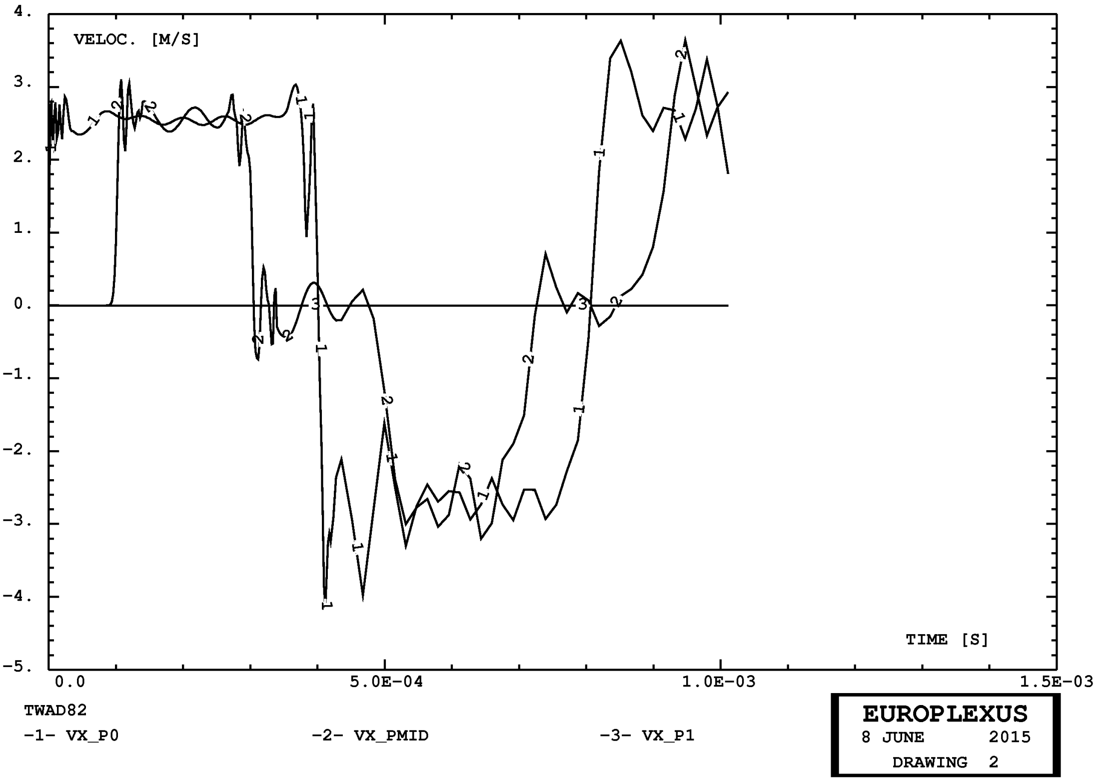

Figure 24 - Velocity of some points of the bar in case TWAD82

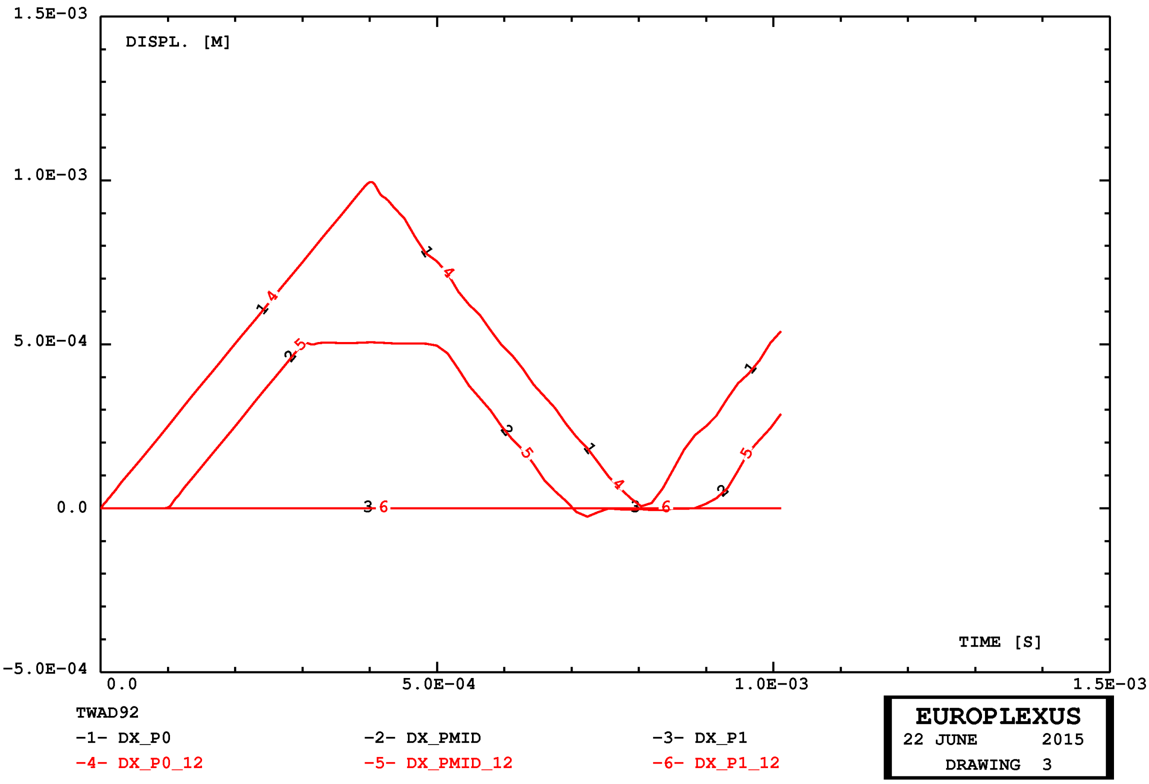

Figure 25 - Comparison of displacements in cases TWAD12 and TWAD92

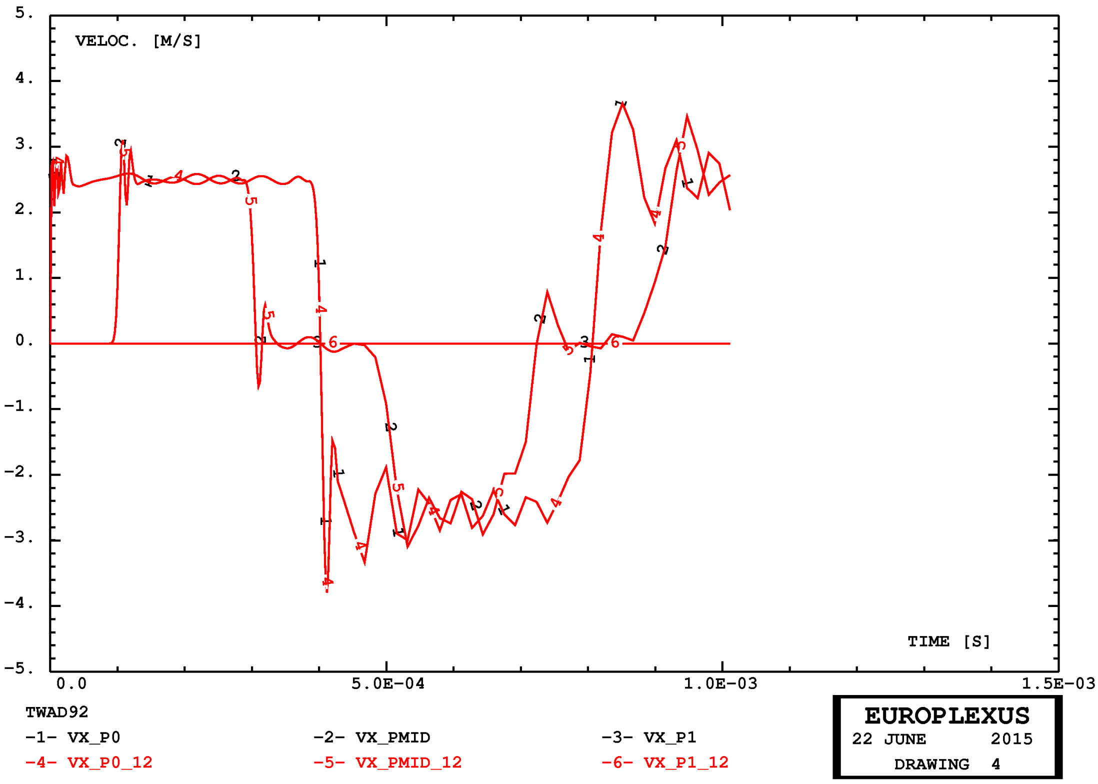

Figure 26 - Comparison of velocities in cases TWAD12 and TWAD92

3.3 Concrete plate

We now consider a more realistic problem than the tests performed so far, actually one of the applications that motivated the current development. A concrete plate meshed by CUBE continuum elements and a DPDC material model is loaded by an applied pressure, see Figure 27. All nodes along the contour of the plate on the first row of base elements are blocked along all global directions, simulating a perfect clamp along the plate perimeter. Adaptivity up to maximum level 4 is prescribed in the plate according to a threshold criterion (ECR(13)) of the DPDC material.

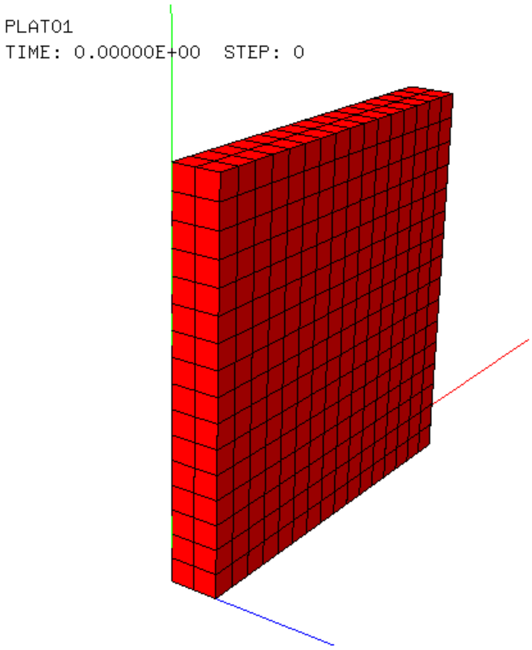

Figure 27 - Base mesh in case PLAT01

The standard solution to this problem (using the fully coupled Lagrange multipliers formulation for hanging nodes and the Cholesky solver) is very expensive in terms of CPU. Figure 28 shows the variation in time of the critical time step, which decreases abruptly at about 1.5 microseconds due to the adaptive refinement of the mesh as the first cracks appear. These results belong to a run of this test case performed before starting the present development.

Although the time step remains almost constant thereafter, the CPU time increases “exponentially” as shown in Figure 29. This is partly due to the increasing number of small elements created as the cracking pattern grows, but also (and mainly) to the increasing number of hanging constraints.

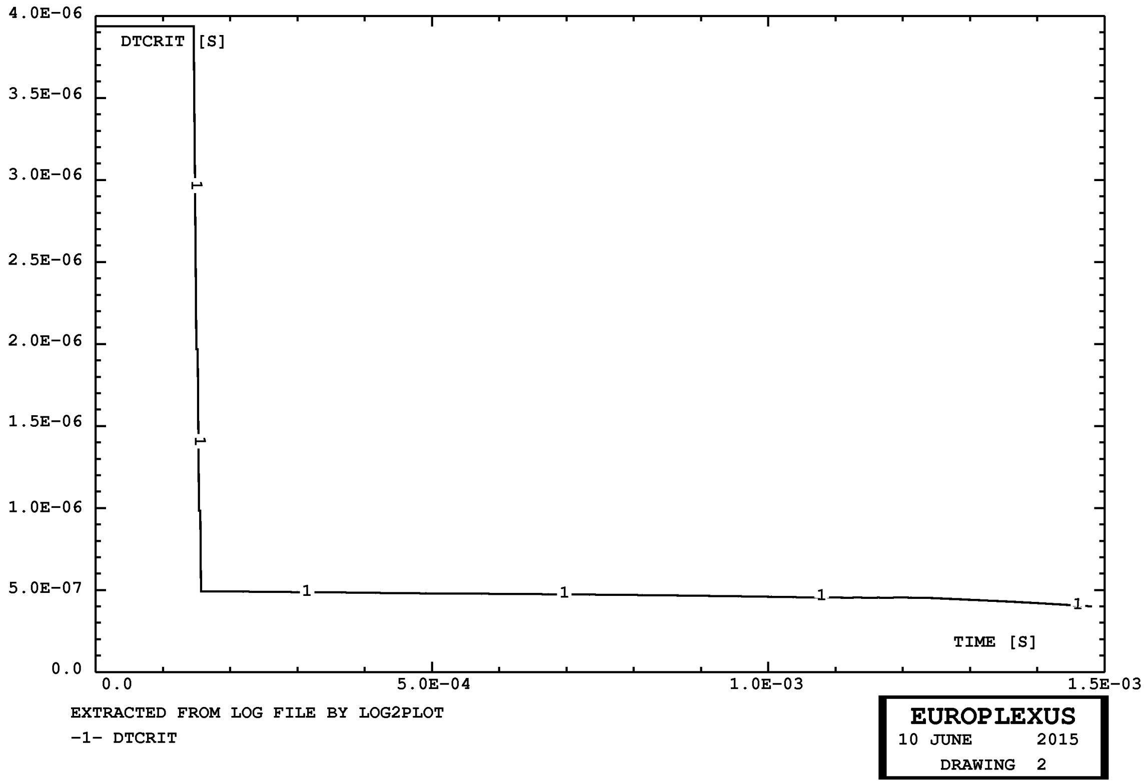

Figure 28 - Critical time step in case PLAT01

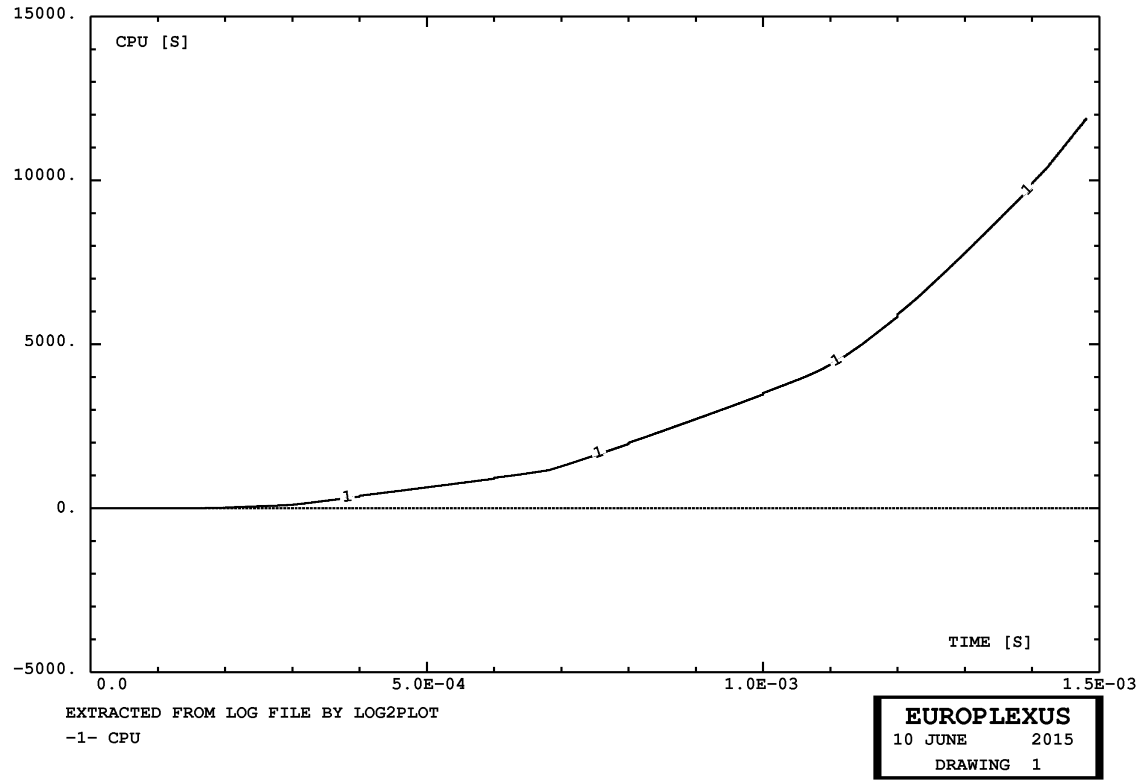

Figure 29 - CPU time in case PLAT01

From the listing and from the .LKS output file (“statistics” file for the links, generated by OPTI LNKS STAT) one can see that at the initial time (base mesh) there are 1,080 links of type BLOQ, the above-mentioned blockages along the plate boundary. Hanging nodes start appearing at step 50, time 0.15 ms, when there are 564 hanging links. However, the number of hanging links increases rapidly. At 1 ms the number of hanging links is 39,681 and the size of the (square) matrix of connections B^* is 42,141. At 1.4 ms the number of hanging links is 57,597 and the size of the (square) matrix of connections B^* is 62,361.

From the graph of the CPU time in Figure 29 one sees that the increase of CPU cost (slope of the curve) is more than linear with the number of hanging constraints, due to (relatively) inefficient solution of the links system as the number of constraints increases. As an example, figure 30 shows the distribution of hanging nodes at 0.2 ms, when there are 4,728 hanging nodes and 14,184 hanging constraints.

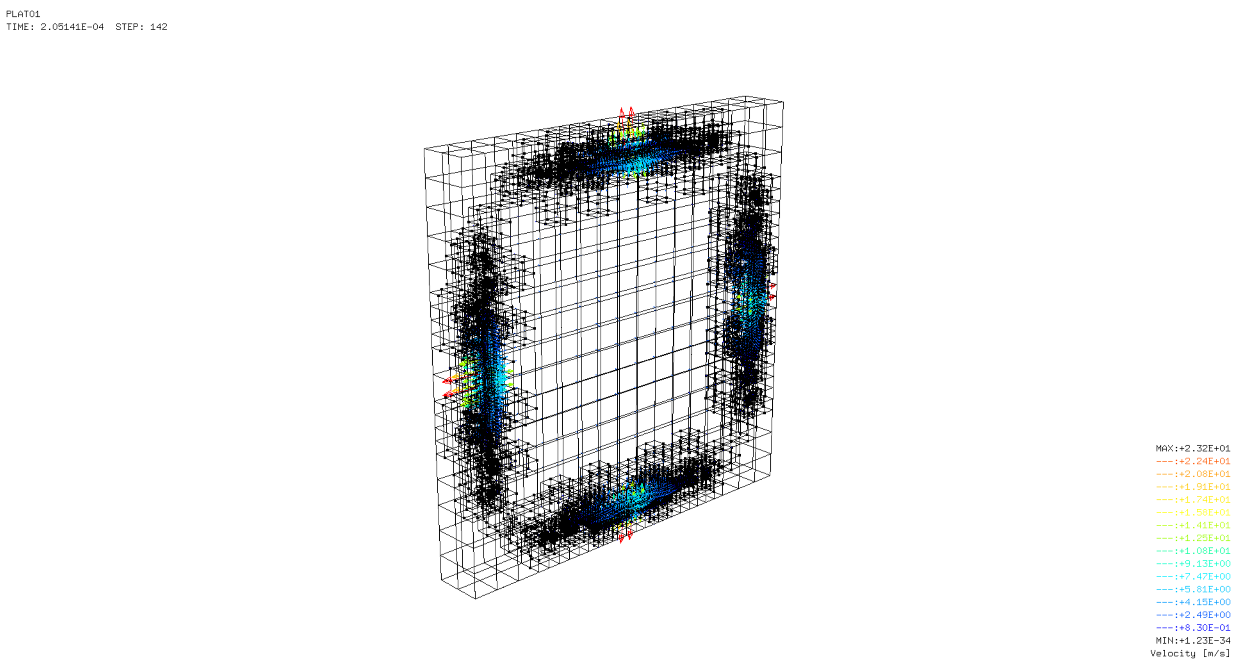

Figure 30 - Hanging nodes at 0.2 ms in case PLAT01

The simulations performed are summarized in Table 3.

Case	Fluid	Structure	FSI	Notes
PLAT00	—	CUBE	—	Reference solution (no option)
PLAT01	—	CUBE	—	OPTI ADAP DHAN
PLAT02	—	CUBE	—	OPTI ADAP WHAN

Table 3 - Test cases for the plate problem

Case	Fluid	Structure	FSI	Notes
PLAT03	—	CUBE	—	Idem PLAT00 but with SOLV PARD

Table 3 - Test cases for the plate problem

PLAT00

We first repeat the standard, reference solution, which uses no particular input option so that the default treatment of hanging nodes by coupled links and Lagrange multipliers is adopted. The final time is limited to 1.0 ms instead of 1.5 ms for brevity.

The solution requires 1,812 time steps and 3,043 s (50.7 minutes) of CPU time.

PLAT01

A first attempt of running this test problem with the new optional keyword OPTI ADAP DHAN fails at step 149, time 0.205 ms and 5.5 s of CPU time, with an error message from the DPDC material routine:

```
ERROR  1 *** M3_DPDC: *** NUMBER OF SUB-STEPS TOO BIG
```

This is thought to be due to numerical oscillations introduced in the solution by the approximated decoupled treatment of links. By reducing the stability safety coefficient from 0.75 to 0.5, instability occurs even earlier (at step 142 and time 0.180 ms) and with CSTA as low as 0.25 the failure occurs even earlier, at step 223 and time 0.170 ms.

An attempt is made to obtain a solution by modifying the material routine for DPDC so that, if no convergence is achieved, the concerned Gauss point is considered as failed and the element is then eroded as soon as a sufficient number of failed Gauss points is reached.

In this way, the code does complete the calculation until the final time. However, almost all elements in the plate get eroded, so that this solution does not look physically correct and is not useful in practice.

PLAT02

This is a repetition of case PLAT00 (with the standard version of the DPDC material routine) by adding the option OPTI ADAP WHAN, which activates weak decoupled treatment of hanging nodes as explained in Section 2.6.

Some more elements get eroded, with respect to the standard solution, and some more elements are needed in the dimensioning for adaptivity, since the zones of refined mesh are somewhat larger. Despite this, the solution looks physical (plate failure is concentrated only in some zones) and the cost in terms of CPU time is much smaller than in the reference.

The solution requires 1,833 time steps and 219 s (3.7 minutes) of CPU time. The speed-up with respect to the reference is 13.9. It should be mentioned that sometimes good speed-ups are obtained also with the coupled links formulation by using a more efficient solver for the system (e.g. SPLIB or Pardiso) instead of the default Cholesky solver, but unfortunately the solution sometimes fails due to internal errors in the supposedly fast solver.

We compare this solution with the reference. In Figure 31 the final (non-eroded) mesh is shown from various viewpoints. The top row is the reference solution and the bottom row is the new solution.

Figure 32 compares the damage in the two solutions, which for the DPDC material is contained in ECR(13).

PLAT03

This is a repetition of case PLAT00 by adding the optional keywords LINK COUP SPLT NONE SOLV PARD, which activated the Pardiso (MKL) solver for sparse systems.

The solution requires 1,812 time steps and 961 s (16 minutes) of CPU time. The speed-up with respect to the reference is 3.2 and the speed-down with respect to the weak uncoupled solution PLAT02 is 4.4.

Results are almost identical to those of the reference solution, see Figure 33.

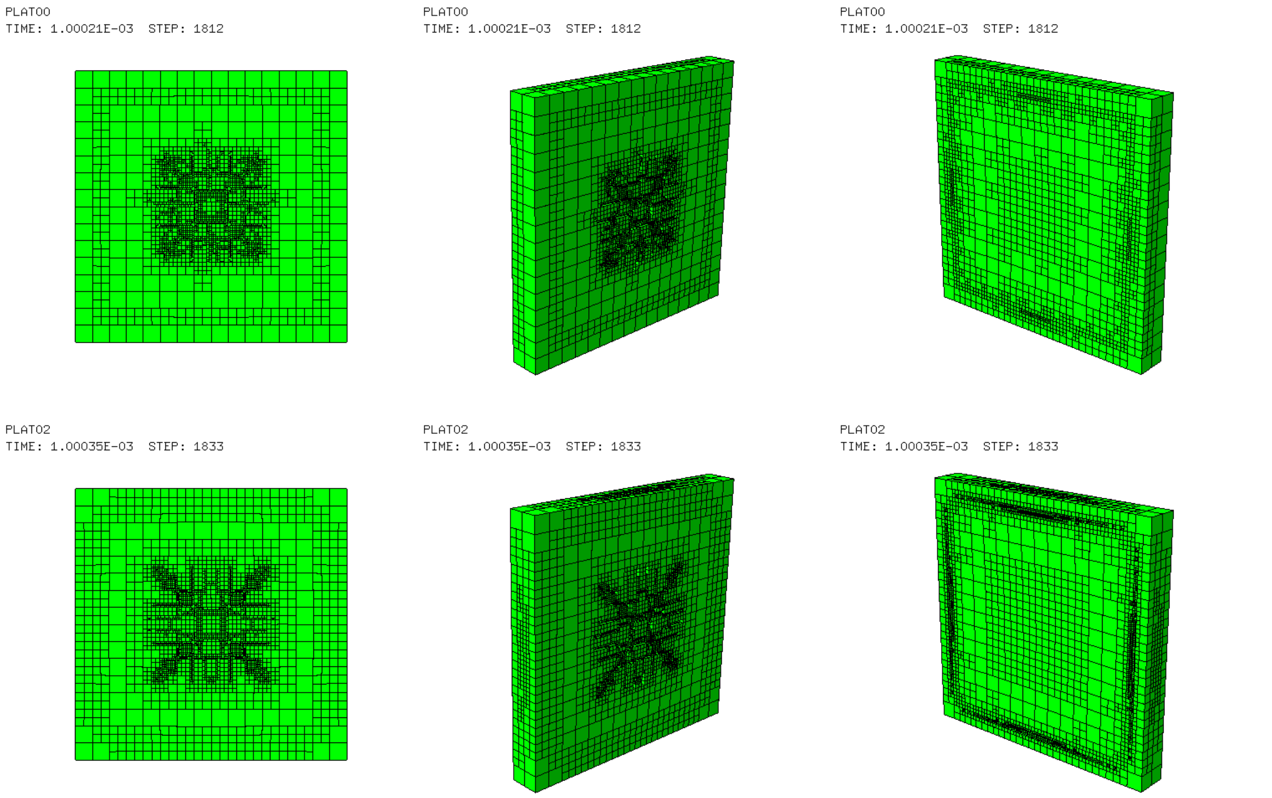

Figure 31 - Comparison of meshes in solutions PLAT00 (top) and PLAT02 (bottom)

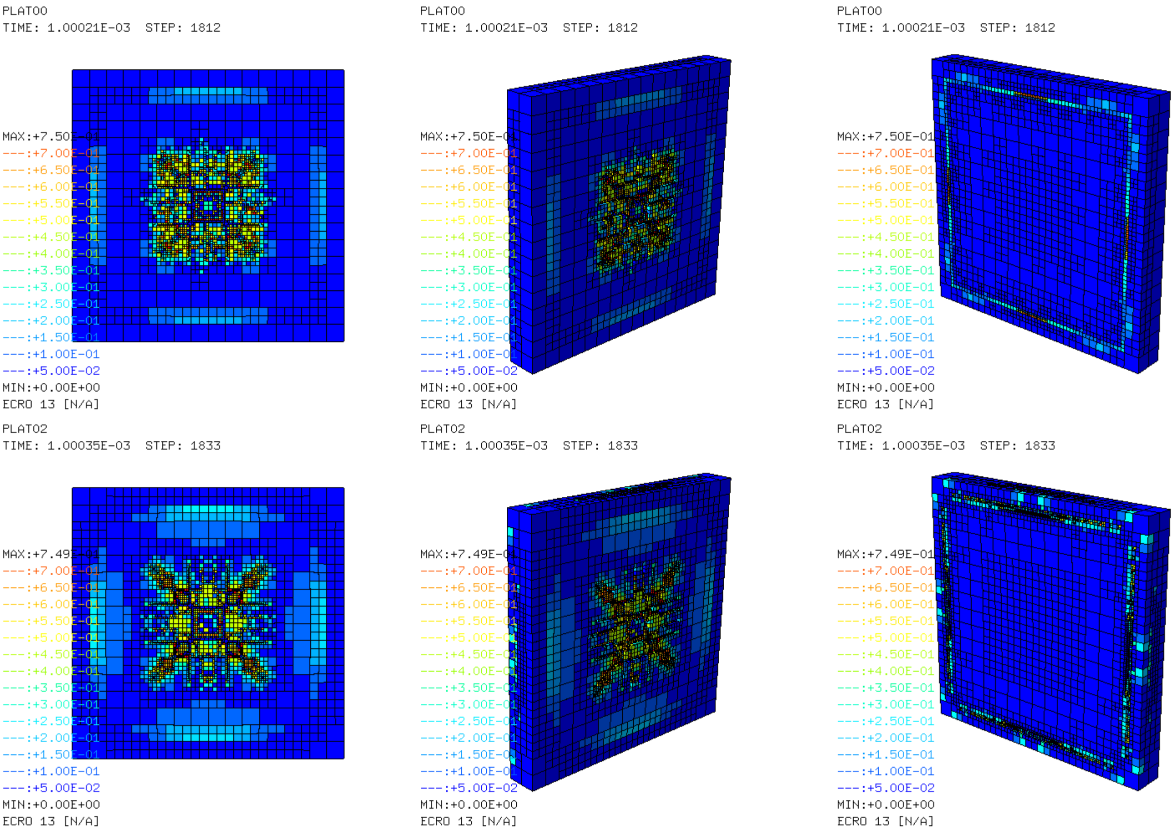

Figure 32 - Comparison of damage in solutions PLAT00 (top) and PLAT02 (bottom)

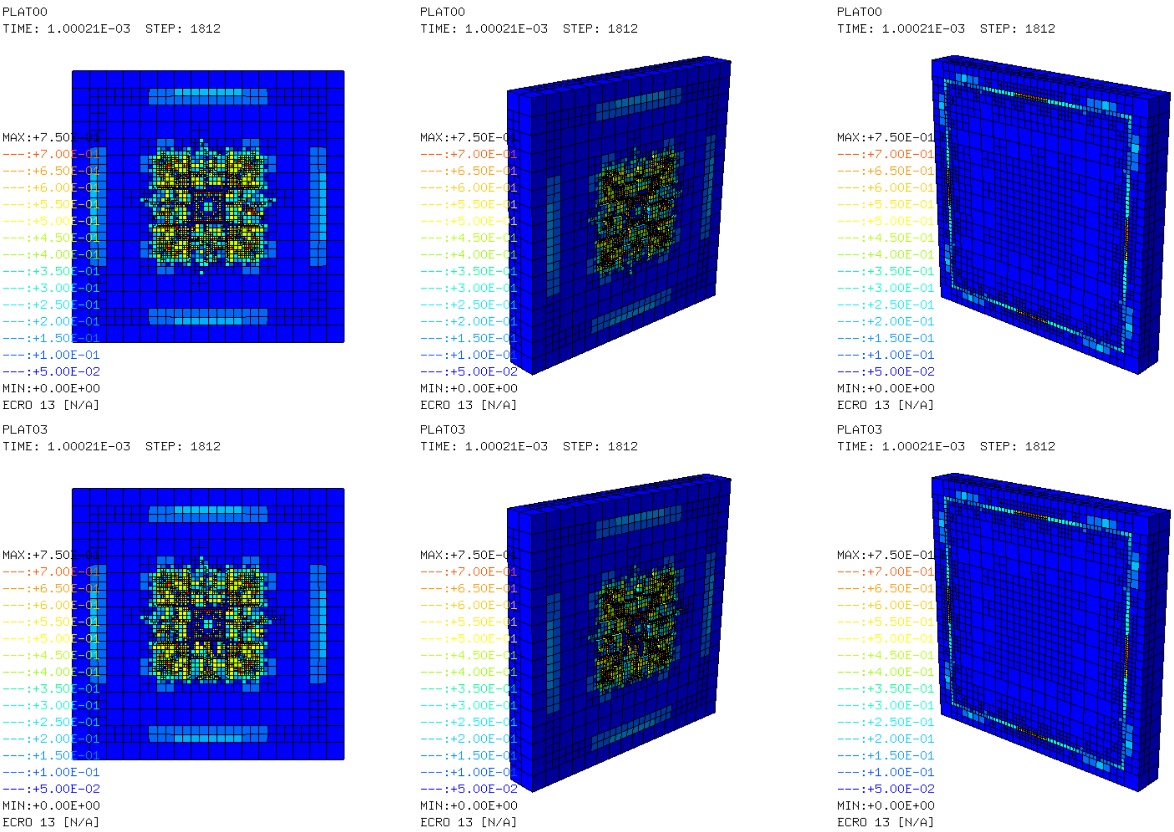

Figure 33 - Comparison of damage in solutions PLAT00 (top) and PLAT03 (bottom)

3.4 Concrete column

We now consider another realistic problem. A concrete column meshed by CUBE continuum elements and a DPDC material model is loaded by an applied pressure, see Figure 34. Some nodes are blocked in order to simulate rigid supports. Adaptivity up to maximum level 4 is prescribed in the plate according to a threshold criterion (ECR(13)) of the DPDC material.

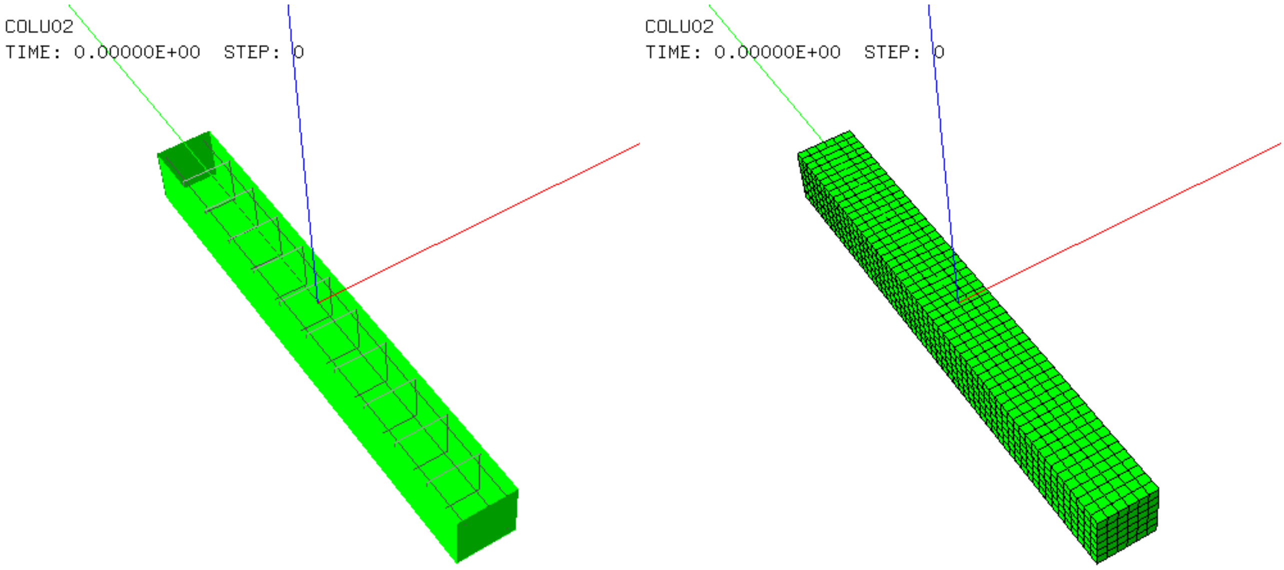

Figure 34 - Base mesh in case COLU02

The real column is reinforced by some steel rebars. These are included in the model (see Figure 34) by means of BR3D elements with the VMIS ISOT material. However, no coupling (ARMA directive) between the bars and the concrete is specified in the initial simulations because at the moment the ARMA directive has not been tested and might be incompatible with adaptivity. Consequently the bars take no load and it is like if they would be completely absent (un-reinforced column).

The simulations performed are summarized in Table 4.

Case	Fluid	Structure	FSI	Notes
COLU02	—	CUBE	—	Reference solution (no option: coupled, Cholesky solver)
COLU02	—	CUBE	—	SOLV PARD (coupled, Pardiso solver)
COLU03	—	CUBE	—	SOLV PARD OPTI ADAP WHAN (decoupled, Pardiso solver)

Table 4 - Test cases for the column problem

COLU00

We first solve the problem without any particular options. This means that the default method of treating hanging nodes is used: fully coupled Lagrange multipliers with Cholesky's solver.

This simulation took 2,345 time steps and 235,550 s (65.5 hours) of CPU up to the final time of 2.5 ms on a computer different from the one used in the previous numerical examples.

COLU02

Then we solve the problem by using the fast Pardiso solver (LINK COUP SOLV PARD) instead of the default Cholesky solver.

This simulation took 2,338 time steps and 9,397 s (2.6 hours) of CPU up to the final time of 2.5 on the same computer as case COLU00, with a speed-up factor of 25.0.

COLU03

Finally, we add the OPTI ADAP WHAN option. This means that the weak decoupled method of treating hanging nodes is used. The Pardiso solver is used, like in the previous calculation.

This simulation took 2,338 time steps and 3,267 s (0.9 hours) of CPU up to the final time of 2.5 ms on the same computer as case COLU02, with a (furher) speed-up factor of 2.9.

Results for the three solutions are compared next, see Figure 35. The "rear" face of the column is the opposite face to the one onto which the pressure is applied. The agreement between the solutions is very good.

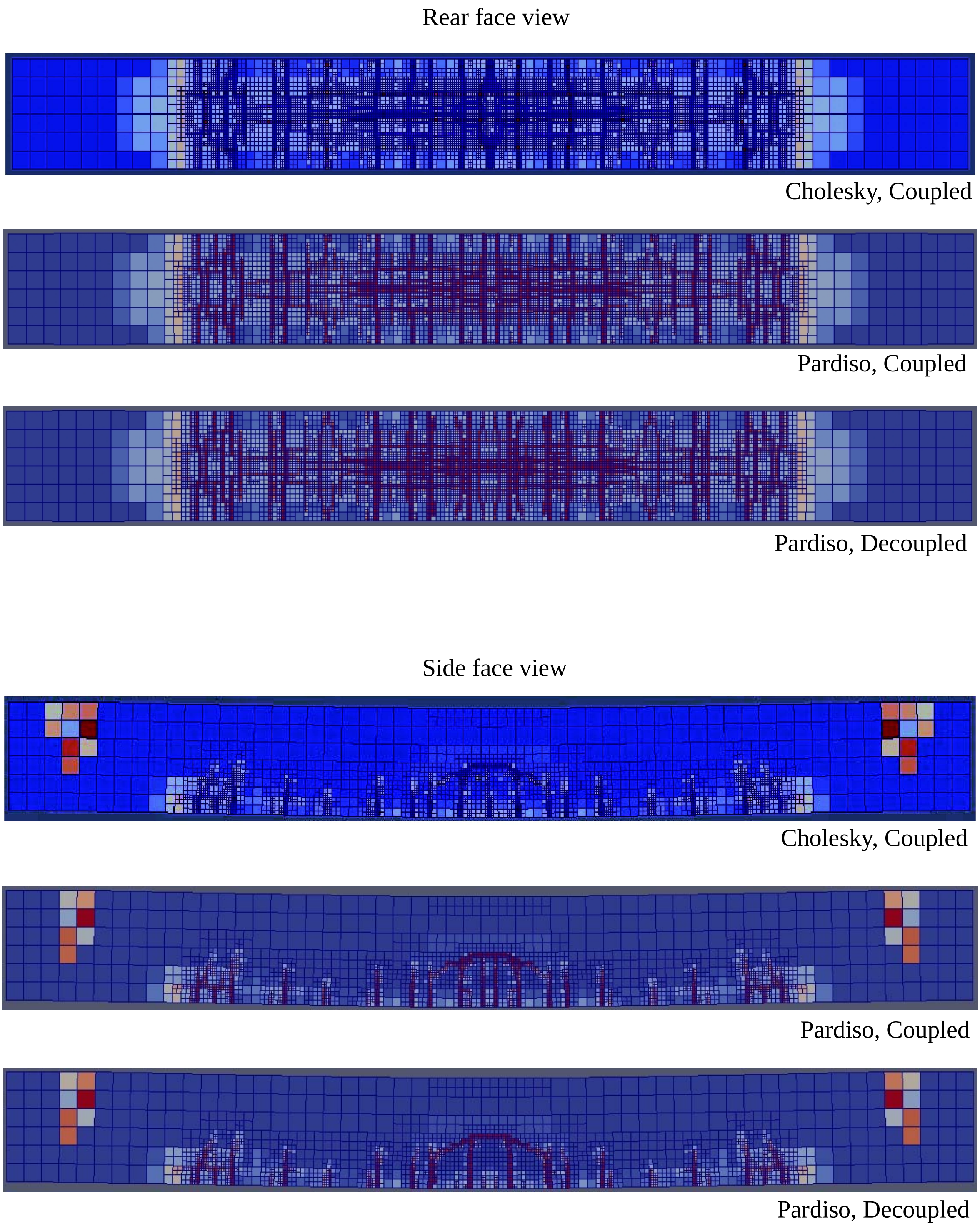

Figure 35 - Comparison of damage in solutions COLU00 (top), COLU02 (middle) and COLU03 (bottom)

3.5 Glass panel

Finally, let us consider a glass panel subjected to an air blast pressure. The panel is meshed by Q4GS shell elements with a sandwich of 3 layers, the external ones made of LSGL glass material and the intermediate one by VM23 material (to simulate PVB), see Figure 36. The external frame of the panel is represented by CUB8 parallelepiped elements (in magenta), with a linear elastic material. The pressure is applied on the face of the panel by means of CL2D elements and an IMPE AIRB material.

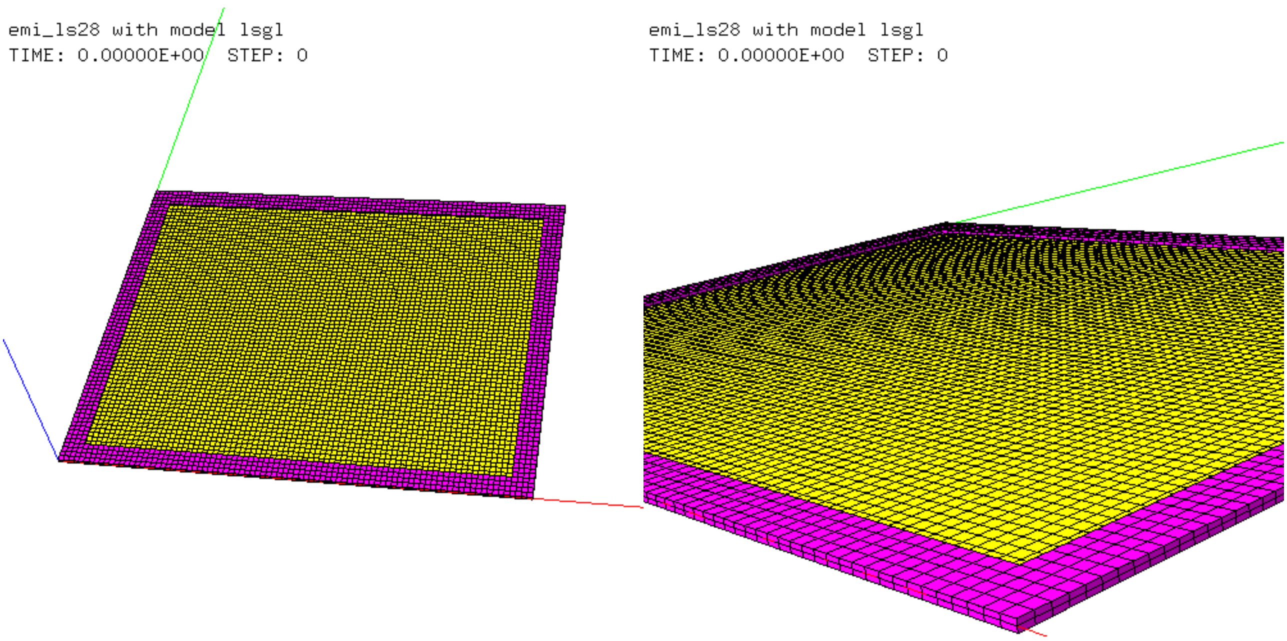

Figure 36 - Base mesh in case COLU02

Adaptivity is activated in the shell elements of the panel by means of the ADAP THRS (threshold) directive, based upon the value of ECR(6) in the material, which represents a failure flag (0 for a virgin Gauss point, 1 for a failed Gauss point) for both the LSGL and the VM23 materials. The idea is to refine the mesh in the failing regions so as to follow the formation and the propagation of cracks.

The simulations performed are summarized in Table 5.

Case	Fluid	Structure	FSI	Notes
EMI_LS28_ADAP_MAXL4	—	Q4GS	—	Reference solution, PARD
EMI_LS28_ADAP_MAXL4_DHAN	—	Q4GS	—	OPTI ADAP DHAN
EMI_LS28_ADAP_MAXL4_WHAN	—	Q4GS	—	OPTI ADAP WHAN

Table 5 - Test cases for the glass panel problem

EMI_LS28_ADAP_MAXL4

We first (attempt to) solve the problem without any particular options. This means that the default method of treating hanging nodes is used: fully coupled Lagrange multipliers. We activate the PARD optional keyword of the LINK COUP directive (LINK COUP SPLT NONE SOLV PARD) in order to activate the Pardiso solver for the linear system, which should be (much) faster than the default solver (Cholesky).

This solution fails upon access violation in M_MKL_OPERATORS module at time 8.28 ms, step 6,991 and after using 15,901 s of CPU (4.4 hours) on the SM02 machine at JRC. As already noted, the Pardiso solver is usually much faster than the Cholesky solver, but not sometimes not as robust.

EMI_LS28_ADAP_MAXL4_DHAN

This test is identical to the previous one but we activate the ADAP DHAN option. The Pardiso solver is kept, but in this case the (coupled) links reduce to some blockages around the panel frame. The calculation proceeds correctly until the final time of 10 ms which is reached in 15,567 time steps and 50,199 s of CPU (14 hours). For comparison with the previous calculation, the CPU time at 8.28 ms (step 6,991) is 11,830 s, i.e. 3.3 hours or a saving of 26% of CPU time with respect to the coupled solution (until it fails).

EMI_LS28_ADAP_MAXL4_WHAN

This test is identical to the previous one but we activate the ADAP WHAN option. The Pardiso solver is kept, but in this case the (coupled) links reduce to some blockages around the panel frame. The calculation proceeds correctly until the final time of 10 ms which is reached in 15,443 time steps and 47,246 s of CPU (13 hours), and is therefore slightly faster than the DHAN solution. For comparison with the first calculation, the CPU time at 8.28 ms (step 6,991) is 11,178 s, i.e. 3.1 hours or a saving of 30% of CPU time with respect to the coupled solution (until it fails). The two solutions with DHAN and WHAN options are compared in Figure 37, showing good overall agreement.

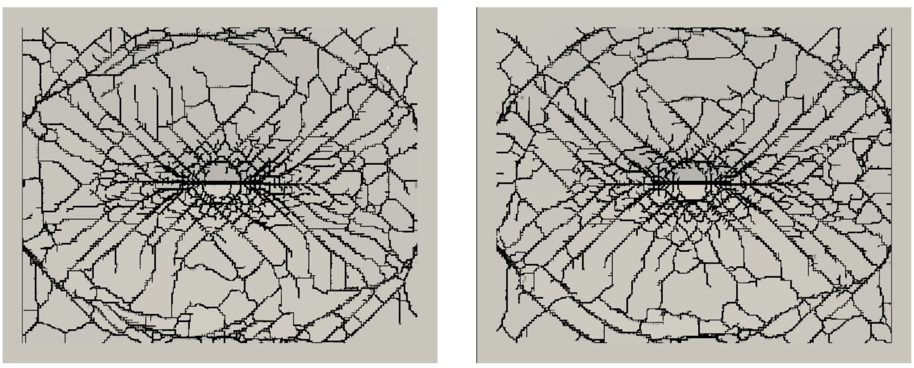

Figure 37 - Comparison of glass panel solutions with DHAN and WHAN options

4. References

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[16] F. CASADEI, V. FAUCHER, M. LARCHER, G. VALSAMOS: "*Combined Fluid and Structure Mesh Adaptivity with Fluid-Structure Interaction in Europlexus*". Technical Note, PUBSY No. JRC96043, EUR Report 27276 EN, 2015.

[17] F. CASADEI, G. VALSAMOS, M. LARCHER: "*On the interpretation and post-processing of mesh-adaptive numerical results in Europlexus*". Technical Note, in publication, 2015.

[18] F. CASADEI: "*Treatment of Essential Boundary Conditions in PLEXIS-3C*", Technical Note N. I.93.91, July 1993.

[19] F. CASADEI: "*A Revision of the Liaisons Model in EUROPLEXUS for Domain Decomposition Calculations*", Technical Note N. I.02.107, November 2002.

[20] "*EUROPLEXUS User's Manual*", on-line version: http://europlexus.jrc.ec.europa.eu.

List of input files

Appendix

Sample input files

This Section contains, in alphabetical file order, the listings of all input files related to the examples which were proposed in the previous Sections.

colu00.dgibi

```
opti echo 1;
opti dime 3 elem cub8;
opti sauv form 'colu00.msh';
opti trac psc ftra 'colu00_mesh.ps';
*
camD = 100.0;
oelz = 0 0 camD;
oel = camD camD camD;
oeln = camD (0 - camD) (0 - camD);
oelm = (0 - camD) (0 + camD) (0 - camD);
tol = 1.E-3;
*Elle = 0.01/3;
Elle = 0.01/2;
ElleC = 0.02;
*
Hcol = 2.2;
Ycl = Hcol/2.0;
Wcl = 0.25;
Xcl = Wcl/2.0;
Dcl = 0.25;
Pcol1 = ((0 - Xcl) (0 - Ycl) 0);
Pcol2 = Pcol1 PLUS (0 Hcol 0);
ElleCC = 2*ElleC;
ncy = ENTI ((Hcol + 0.0001) / (ElleCC));
cc1 = Pcol1 D ncy Pcol2;
ncx = ENTI ((Wcl + 0.0001) / (ElleCC));
list ncx;
sc1 = cc1 TRAN ncx (Wcl 0 0);
ncz = ENTI ((Dcl + 0.0001) / (ElleCC));
vc1 = (sc1) VOLU TRAN ncz (0 0 (0 - Dcl));
Dri = 0.035;
Pri1 = Pcol1 PLUS ((0 + Dri) 0 (0 - Dri));
Pri2 = Pri1 PLUS (0 Hcol 0);
cri1 = Pri1 D ncy Pri2;
ritr = Wcl - (2*Dri);
cri2 = cri1 PLUS ((ritr) 0 0);
cri3 = cri2 PLUS (0 0 (0 - ritr));
cri4 = cri1 PLUS (0 0 (0 - ritr));
barsV = cri1 ET cri2 ET cri3 ET cri4;
DriS = 0.015;
HriS = 0.2;
PriS1 = Pcol1 PLUS ((0 + DriS) HriS (0 - DriS));
ritrS = Wcl - (2*DriS);
PriS2 = PriS1 PLUS ((ritrS) 0 0);
PriS3 = PriS2 PLUS (0 0 (0 - ritrS));
PriS4 = PriS1 PLUS (0 0 (0 - ritrS));
nriS = ENTI ((ritrS + 0.0001) / (ElleCC));
criSa = PriS1 D nriS PriS2;
criSb = PriS2 D nriS PriS3;
criSc = PriS3 D nriS PriS4;
criSd = PriS4 D nriS PriS1;
barS1 = criSa ET criSb ET criSc ET criSd;
barS2 = barS1 PLUS (0 Hris 0);
barS3 = barS2 PLUS (0 Hris 0);
barS4 = barS3 PLUS (0 Hris 0);
barS5 = barS4 PLUS (0 Hris 0);
barS6 = barS5 PLUS (0 Hris 0);
barS7 = barS6 PLUS (0 Hris 0);
barS8 = barS7 PLUS (0 Hris 0);
barS9 = barS8 PLUS (0 Hris 0);
barS10 = barS9 PLUS (0 Hris 0);
barsS = barS1 ET barS2 ET barS3 ET barS4 ET barS5
ET barS6 ET barS7 ET barS8 ET barS9 ET barS10;
*
bars = barsV ET barsS;
TRAC oel cach qual (bars);
TRAC oel cach qual (vc1 ET cri1);
*
pres = sc1 PLUS (0 0 0);
mesh = vc1 ET bars ET pres;
TRAC oel CACH QUAL (mesh);
TRAC oeln CACH QUAL (mesh);
mesh = mesh coul jaun;
elim tol mesh;
hexa = mesh ELEM 'CUB8';
TASS mesh NOOP;
SAUV FORM mesh;
LIST (NBEL mesh);
LIST (NBEL hexa);
LIST (NBEL pres);
LIST (NBEL bars);
LIST (NBNO mesh);
*
TRAC oel CACH QUAL (mesh);
*
fin;
```

colu00.epx

```
COLU00
ECHO
 CONV WIN
CAST mesh
TRID LAGR EROS 0.0
DIME ADAP NPOI 550000 CUBE 580000 CL3Q 2000 ENDA TERM
GEOM CUBE vc1 BR3D bars CL3Q pres TERM
COMP EPAI 1.131E-4 LECT barsV TERM
     EPAI 0.50265E-4 LECT barsS TERM
     GROU 3 'cele1' LECT vc1 TERM
                COND NEAR POIN 0.0 0.0 0.0
            'cele2' LECT vc1 TERM
                COND NEAR POIN 0.0 0.0 -0.25
            'EROA' LECT vc1 TERM
                COND YB LT 0.7
                COND YB GT -0.7
     NGRO 3 'DOWN' LECT mesh TERM COND Y LT -1.0
            'UP'   LECT mesh TERM COND Y GT 1.0
            'cen'  LECT vc1 TERM COND NEAR POIN 0.0 0.0 -2.5
     COUL VERT LECT vc1  TERM
          JAUN LECT pres TERM
          GR50 LECT bars TERM
ADAP THRS ECRO 13 TMIN 0.1 TMAX 0.5 MAXL 4
          LECT EROA TERM
MATE VMIS ISOT RO 7800 YOUN 200E9 NU 0.3 ELAS 450.E6
          FAIL 2 LIMI 0.18
          TRAC 2  450.E6    0.00225
                  510.E6    0.18
          LECT bars term
     DPDC RO 2400 YOUN 30E+9 NU 0.21
          FC 20.E+6 DAGG 20.0E-3  VERS 8
          LECT vc1 _cube TERM
     IMPE AIRB X 0.0 Y 0.0 Z 7
          MASS 500 TAUT !OPOS
          LECT pres _cl3q TERM
LINK COUP SPLT NONE
          BLOQ 123 LECT UP DOWN TERM
REGI 'CEN' DIMX POIN LECT cen TERM
ECRI DEPL TFRE 0.1E-3
           POINT LECT cen TERM
           ELEM  LECT 1 TERM
     FICH SPLI ALIC TFRE 0.5E-3
     FICH FORM PVTK TFRE 0.1e-3
          VARI DEPL ECRO VITE
OPTI NOTE
     CSTA 0.8
     ADAP RCON STAT
     LOG 1
CALC TINI 0 TEND 3.6E-3
FIN
```

colu02.dgibi

```
opti echo 1;
opti dime 3 elem cub8;
opti sauv form 'colu02.msh';
opti trac psc ftra 'colu02_mesh.ps';
*
camD = 100.0;
oelz = 0 0 camD;
oel = camD camD camD;
oeln = camD (0 - camD) (0 - camD);
oelm = (0 - camD) (0 + camD) (0 - camD);
tol = 1.E-3;
*Elle = 0.01/3;
Elle = 0.01/2;
ElleC = 0.02;
*
Hcol = 2.2;
Ycl = Hcol/2.0;
Wcl = 0.25;
Xcl = Wcl/2.0;
Dcl = 0.25;
Pcol1 = ((0 - Xcl) (0 - Ycl) 0);
Pcol2 = Pcol1 PLUS (0 Hcol 0);
ElleCC = 2*ElleC;
ncy = ENTI ((Hcol + 0.0001) / (ElleCC));
cc1 = Pcol1 D ncy Pcol2;
ncx = ENTI ((Wcl + 0.0001) / (ElleCC));
list ncx;
sc1 = cc1 TRAN ncx (Wcl 0 0);
ncz = ENTI ((Dcl + 0.0001) / (ElleCC));
vc1 = (sc1) VOLU TRAN ncz (0 0 (0 - Dcl));
Dri = 0.035;
Pri1 = Pcol1 PLUS ((0 + Dri) 0 (0 - Dri));
Pri2 = Pri1 PLUS (0 Hcol 0);
cri1 = Pri1 D ncy Pri2;
ritr = Wcl - (2*Dri);
cri2 = cri1 PLUS ((ritr) 0 0);
cri3 = cri2 PLUS (0 0 (0 - ritr));
cri4 = cri1 PLUS (0 0 (0 - ritr));
barsV = cri1 ET cri2 ET cri3 ET cri4;
DriS = 0.015;
HriS = 0.2;
PriS1 = Pcol1 PLUS ((0 + DriS) HriS (0 - DriS));
ritrS = Wcl - (2*DriS);
PriS2 = PriS1 PLUS ((ritrS) 0 0);
PriS3 = PriS2 PLUS (0 0 (0 - ritrS));
PriS4 = PriS1 PLUS (0 0 (0 - ritrS));
nriS = ENTI ((ritrS + 0.0001) / (ElleCC));
criSa = PriS1 D nriS PriS2;
criSb = PriS2 D nriS PriS3;
criSc = PriS3 D nriS PriS4;
criSd = PriS4 D nriS PriS1;
barS1 = criSa ET criSb ET criSc ET criSd;
barS2 = barS1 PLUS (0 Hris 0);
barS3 = barS2 PLUS (0 Hris 0);
barS4 = barS3 PLUS (0 Hris 0);
barS5 = barS4 PLUS (0 Hris 0);
barS6 = barS5 PLUS (0 Hris 0);
barS7 = barS6 PLUS (0 Hris 0);
barS8 = barS7 PLUS (0 Hris 0);
barS9 = barS8 PLUS (0 Hris 0);
barS10 = barS9 PLUS (0 Hris 0);
barsS = barS1 ET barS2 ET barS3 ET barS4 ET barS5
ET barS6 ET barS7 ET barS8 ET barS9 ET barS10;
*
bars = barsV ET barsS;
TRAC oel cach qual (bars);
TRAC oel cach qual (vc1 ET cri1);
*
pres = sc1 PLUS (0 0 0);
```

```
mesh = vc1 ET bars ET pres;
TRAC oel CACH QUAL (mesh);
TRAC oeln CACH QUAL (mesh);
mesh = mesh coul jaun;
elim tol mesh;
hexa = mesh ELEM 'CUB8';
TASS mesh NOOP;
SAUV FORM mesh;
LIST (NBEL mesh);
LIST (NBEL hexa);
LIST (NBEL pres);
LIST (NBEL bars);
LIST (NBNO mesh);
*
TRAC oel CACH QUAL (mesh);
*
fin;
```

colu02.epx

```
COLU02
ECHO
 CONV WIN
CAST mesh
TRID LAGR EROS 0.0
DIME ADAP NPOI 550000 CUBE 580000 CL3Q 2000 ENDA TERM
GEOM CUBE vc1 BR3D bars CL3Q pres TERM
COMP EPAI 1.131E-4 LECT barsV TERM
     EPAI 0.50265E-4 LECT barsS TERM
     GROU 3 'cele1' LECT vc1 TERM
                   COND NEAR POIN 0.0 0.0 0.0
            'cele2' LECT vc1 TERM
                   COND NEAR POIN 0.0 0.0 -0.25
            'EROA' LECT vc1 TERM
                   COND YB LT 0.7
                   COND YB GT -0.7
     NGRO 3 'DOWN' LECT mesh TERM COND Y LT -1.0
            'UP'   LECT mesh TERM COND Y GT 1.0
            'cen'  LECT vc1 TERM COND NEAR POIN 0.0 0.0 -2.5
     COUL VERT LECT vc1  TERM
          JAUN LECT pres TERM
          GR50 LECT bars TERM
ADAP THRS ECRO 13 TMIN 0.1 TMAX 0.5 MAXL 4
          LECT EROA TERM
MATE VMIS ISOT RO 7800 YOUN 200E9 NU 0.3 ELAS 450.E6
          FAIL 2 LIMI 0.18
          TRAC 2  450.E6    0.00225
                  510.E6    0.18
          LECT bars term
     DPDC RO 2400 YOUN 30E+9 NU 0.21
          FC 20.E+6 DAGG 20.0E-3  VERS 8
          LECT vc1 _cube TERM
     IMPE AIRB X 0.0 Y 0.0 Z 7
          MASS 500 TAUT !OPOS
          LECT pres _cl3q TERM
LINK COUP SOLV PARD
          SPLT NONE
          BLOQ 123 LECT UP DOWN TERM
REGI 'CEN' DIMX POIN LECT cen TERM
ECRI DEPL TFRE 0.1E-3
           POINT LECT cen TERM
           ELEM  LECT 1 TERM
     FICH SPLI ALIC TFRE 0.5E-3
     FICH FORM PVTK TFRE 0.1e-3
          VARI DEPL ECRO VITE
OPTI NOTE
     CSTA 0.8
     ADAP RCON STAT
     LOG 1
CALC TINI 0 TEND 3.6E-3
FIN
```

colu03.dgibi

```
opti echo 1;
opti dime 3 elem cub8;
opti sauv form 'colu03.msh';
opti trac psc ftra 'colu03_mesh.ps';
*
camD = 100.0;
oelz = 0 0 camD;
oel = camD camD camD;
oeln = camD (0 - camD) (0 - camD);
oelm = (0 - camD) (0 + camD) (0 - camD);
tol = 1.E-3;
*Elle = 0.01/3;
Elle = 0.01/2;
ElleC = 0.02;
*
Hcol = 2.2;
Ycl = Hcol/2.0;
Wcl = 0.25;
Xcl = Wcl/2.0;
Dcl = 0.25;
Pcol1 = ((0 - Xcl) (0 - Ycl) 0);
Pcol2 = Pcol1 PLUS (0 Hcol 0);
ElleCC = 2*ElleC;
ncy = ENTI ((Hcol + 0.0001) / (ElleCC));
cc1 = Pcol1 D ncy Pcol2;
ncx = ENTI ((Wcl + 0.0001) / (ElleCC));
list ncx;
sc1 = cc1 TRAN ncx (Wcl 0 0);
ncz = ENTI ((Dcl + 0.0001) / (ElleCC));
vc1 = (sc1) VOLU TRAN ncz (0 0 (0 - Dcl));
Dri = 0.035;
Pri1 = Pcol1 PLUS ((0 + Dri) 0 (0 - Dri));
Pri2 = Pri1 PLUS (0 Hcol 0);
cri1 = Pri1 D ncy Pri2;
ritr = Wcl - (2*Dri);
cri2 = cri1 PLUS ((ritr) 0 0);
cri3 = cri2 PLUS (0 0 (0 - ritr));
cri4 = cri1 PLUS (0 0 (0 - ritr));
barsV = cri1 ET cri2 ET cri3 ET cri4;
DriS = 0.015;
HriS = 0.2;
PriS1 = Pcol1 PLUS ((0 + DriS) HriS (0 - DriS));
ritrS = Wcl - (2*DriS);
PriS2 = PriS1 PLUS ((ritrS) 0 0);
PriS3 = PriS2 PLUS (0 0 (0 - ritrS));
PriS4 = PriS1 PLUS (0 0 (0 - ritrS));
nriS = ENTI ((ritrS + 0.0001) / (ElleCC));
criSa = PriS1 D nriS PriS2;
criSb = PriS2 D nriS PriS3;
criSc = PriS3 D nriS PriS4;
criSd = PriS4 D nriS PriS1;
barS1 = criSa ET criSb ET criSc ET criSd;
barS2 = barS1 PLUS (0 Hris 0);
barS3 = barS2 PLUS (0 Hris 0);
barS4 = barS3 PLUS (0 Hris 0);
barS5 = barS4 PLUS (0 Hris 0);
barS6 = barS5 PLUS (0 Hris 0);
barS7 = barS6 PLUS (0 Hris 0);
barS8 = barS7 PLUS (0 Hris 0);
barS9 = barS8 PLUS (0 Hris 0);
barS10 = barS9 PLUS (0 Hris 0);
barsS = barS1 ET barS2 ET barS3 ET barS4 ET barS5
ET barS6 ET barS7 ET barS8 ET barS9 ET barS10;
*
bars = barsV ET barsS;
TRAC oel cach qual (bars);
TRAC oel cach qual (vc1 ET cri1);
*
pres = sc1 PLUS (0 0 0);
mesh = vc1 ET bars ET pres;
TRAC oel CACH QUAL (mesh);
TRAC oeln CACH QUAL (mesh);
mesh = mesh coul jaun;
elim tol mesh;
hexa = mesh ELEM 'CUB8';
TASS mesh NOOP;
SAUV FORM mesh;
LIST (NBEL mesh);
LIST (NBEL hexa);
LIST (NBEL pres);
LIST (NBEL bars);
LIST (NBNO mesh);
*
TRAC oel CACH QUAL (mesh);
*
fin;
```

colu03.epx

```
COLU03
ECHO
 CONV WIN
CAST mesh
TRID LAGR EROS 0.0
DIME ADAP NPOI 550000 CUBE 580000 CL3Q 2000 ENDA TERM
GEOM CUBE vc1 BR3D bars CL3Q pres TERM
COMP EPAI 1.131E-4 LECT barsV TERM
     EPAI 0.50265E-4 LECT barsS TERM
     GROU 3 'cele1' LECT vc1 TERM
                   COND NEAR POIN 0.0 0.0 0.0
            'cele2' LECT vc1 TERM
                   COND NEAR POIN 0.0 0.0 -0.25
            'EROA' LECT vc1 TERM
                   COND YB LT 0.7
                   COND YB GT -0.7
     NGRO 3 'DOWN' LECT mesh TERM COND Y LT -1.0
            'UP'   LECT mesh TERM COND Y GT 1.0
            'cen'  LECT vc1 TERM COND NEAR POIN 0.0 0.0 -2.5
     COUL VERT LECT vc1  TERM
          JAUN LECT pres TERM
          GR50 LECT bars TERM
ADAP THRS ECRO 13 TMIN 0.1 TMAX 0.5 MAXL 4
          LECT EROA TERM
MATE VMIS ISOT RO 7800 YOUN 200E9 NU 0.3 ELAS 450.E6
          FAIL 2 LIMI 0.18
          TRAC 2  450.E6    0.00225
                  510.E6    0.18
          LECT bars term
     DPDC RO 2400 YOUN 30E+9 NU 0.21
          FC 20.E+6 DAGG 20.0E-3  VERS 8
          LECT vc1 _cube TERM
     IMPE AIRB X 0.0 Y 0.0 Z 7
          MASS 500 TAUT !OPOS
          LECT pres _cl3q TERM
LINK COUP SOLV PARD
          SPLT NONE
          BLOQ 123 LECT UP DOWN TERM
REGI 'CEN' DIMX POIN LECT cen TERM
ECRI DEPL TFRE 0.1E-3
           POINT LECT cen TERM
           ELEM  LECT 1 TERM
     FICH SPLI ALIC TFRE 0.5E-3
     FICH FORM PVTK TFRE 0.1e-3
          VARI DEPL ECRO VITE
OPTI NOTE
     CSTA 0.8
     ADAP RCON STAT WHAN
     LOG 1
CALC TINI 0 TEND 3.6E-3
FIN
```

emi_ls28.dgibi

```
OPTI echo 1;
OPTI dime 3 elem cub8;
den=0.0125;
DENS den;
sizx = 1.1;
sizy = 0.9;
rand = 0.05;
b11 = rand rand 0;
b12 = (sizx-rand) rand 0;
```

```
b13 = (sizx-rand) (sizy-rand) 0;
b14 = rand (sizy-rand) 0;
li1 = b11 d b12 d b13 d b14 d;
a_airb = surf li1 plan;

b31 = 0 0 0;
b32 = sizx 0 0;
b33 = 0 rand 0;
b34 = sizx rand 0;
li3 = b31 d b32 d b34 d b33 d;
a3 = surf li3 plan;

b41 = sizx sizy 0;
b51 = 0 sizy 0;
b52 = 0 (sizy-rand) 0;
b53 = sizx (sizy-rand) 0;
li4 = b34 d b53 d b13 d b12 d;
a4 = surf li4 plan;


li5 = b41 d b51 d b52 d b53 d;
a5 = surf li5 plan;

li6 = b33 d b11 d b14 d b52 d;
a6 = surf li6 plan;

a_rand = a3 et a4 et a5 et a6;
a_glass1 = a_airb et a_rand;

p1 = 0 0 0.004;
p2 = 0 0 -0.004;
v1 = a_rand volu 'TRAN' p1;
v1 = v1 et (a_rand volu 'TRAN' p2);

ch1 = ((sizx+rand)/2.) ((sizy+rand)/2.) 1.8;

pcent = ((sizx+rand)/2.) ((sizy+rand)/2.) 0;

pdis = a_glass1 poin 'PROC' pcent;

edis1 = a_glass1 ELEM CONTENANT pdis;

a_v1 = v1 enve;

kod1 = faux;
REPE I0 (NBEL (a_v1 ELEM QUA4));
  xx yy zz = coor (bary (a_v1 ELEM QUA4 &I0));
  SI ( zz ega 0.004 0.001);
     si (kod1);bound=bound et (a_v1 ELEM QUA4 &I0);
     sinon; bound = a_v1 ELEM QUA4 &I0;kod1 = vrai;
     fins;
  FINS;
  SI ( zz ega -0.004 0.001);
     si (kod1);bound=bound et (a_v1 ELEM QUA4 &I0);
     sinon; bound = a_v1 ELEM QUA4 &I0;kod1 = vrai;
     fins;
  FINS;
FIN I0;


modell = v1 et a_glass1 et a_airb et pdis et
        edis1 et ch1 et bound;
elim modell;

TASS modell;
OPTI sauv form 'emi_ls28.msh';
sauv form modell;
*
```

emi_ls28_adap_maxl4.epx

```
emi_ls28 with model lsgl
$
 ECHO
! VERI
 CONV WIN
CAST 'emi_ls28.msh' modell
TRID LAGR EROS 1.0
OPTI TOLC 1e-1
DIME
  ADAP NPOI 1000000 Q4GS 400000 CL3D 400000
  ENDA
  TERM
$
GEOM
  CUB8 v1
  Q4GS a_glass1
  CL3D a_airb
TERM
$
COMP
 EPAI 0.0075 LECT a_glass1 _Q4GS TERM
 SAND    3
  FRAC 0.4 0.2 0.4
  NGPZ   2 1 2
  LECT a_glass1 _Q4GS term
   ADAP THRS ECRO 6 TMIN 0.0 TMAX 0.4 MAXL 4 LECT a_glass1 TERM
MATE
      LSGL RO 2500 YOUN 7E10 NU 0.23 CORR 16.0 REDU 0.0
           FAIL PEPR LIMI 0.0012
           LECT a_glass1 _Q4GS TERM
           laye lect 1 3 term
      VM23 RO 1100. YOUNG 3E6 NU 0.46 ELAS 3.45E9
           TRAC 1 3.45E9 1150
           LECT a_glass1 _Q4GS TERM
           laye lect 2 term
      GLIN RO 2770. YOUNG 3.5e6 NU 0.42
           LECT v1 TERM
      IMPE AIRB NODE LECT ch1 TERM CONF 1 MASS 0.09 TAUT
           LECT a_airb _CL3D TERM
LINK COUP SPLT NONE SOLV PARD
     BLOQ 123 bound TERM

ECRI FICH PVTK TFRE 5e-5 VARI ECRO CONT DEPL FEXT FINT VITE FAIL
             GROU AUTO
     FICH ALIC TEMP tfreq 1e-5
               POIN LECT pdis TERM
               ELEM LECT 4148 1628 1698 edis1 TERM
$
OPTI NOTE LOG 1
ADAP RCON
$
CALC TINI 0 TEND 10e-3
*===============================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
*
RESU ALIC TEMP GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'sig_edis' CONT COMP 1 GAUZ 0 ELEM LECT 4148 TERM
COUR 2 'sig_edis' CONT COMP 2 GAUZ 0 ELEM LECT 4148 TERM
COUR 3 'sig_edis' ECRO COMP 12 GAUZ 0 ELEM LECT 4148 TERM
COUR 4 'sig_edis' ECRO COMP 9 GAUZ 0 ELEM LECT 4148 TERM
COUR 5 'sig_edis' ECRO COMP 4 GAUZ 0 ELEM LECT 4148 TERM
COUR 6 'sig_edis' ECRO COMP 5 GAUZ 0 ELEM LECT 4148 TERM
COUR 7 'sig_edis' ECRO COMP 8 GAUZ 0 ELEM LECT 4148 TERM
COUR 11 'sig_edis' CONT COMP 1 GAUZ 0 ELEM LECT 1628 TERM
COUR 12 'sig_edis' CONT COMP 2 GAUZ 0 ELEM LECT 1628 TERM
COUR 13 'sig_edis' ECRO COMP 12 GAUZ 0 ELEM LECT 1628 TERM
COUR 14 'sig_edis' ECRO COMP 9 GAUZ 0 ELEM LECT 1628 TERM
COUR 15 'sig_edis' ECRO COMP 4 GAUZ 0 ELEM LECT 1628 TERM
COUR 16 'sig_edis' ECRO COMP 5 GAUZ 0 ELEM LECT 1628 TERM
COUR 17 'sig_edis' ECRO COMP 8 GAUZ 0 ELEM LECT 1628 TERM
COUR 21 'sig_edis' CONT COMP 1 GAUZ 0 ELEM LECT 1698 TERM
COUR 22 'sig_edis' CONT COMP 2 GAUZ 0 ELEM LECT 1698 TERM
COUR 23 'sig_edis' ECRO COMP 12 GAUZ 0 ELEM LECT 1698 TERM
COUR 24 'sig_edis' ECRO COMP 9 GAUZ 0 ELEM LECT 1698 TERM
COUR 25 'sig_edis' ECRO COMP 4 GAUZ 0 ELEM LECT 1698 TERM
COUR 26 'sig_edis' ECRO COMP 5 GAUZ 0 ELEM LECT 1698 TERM
COUR 27 'sig_edis' ECRO COMP 8 GAUZ 0 ELEM LECT 1698 TERM
COUR 9 SOMME 3 5 1 6 1 7 1
COUR 19 SOMME 3 15 1 16 1 17 1
COUR 29 SOMME 3 25 1 26 1 27 1
COUR 99 'dz_pdis' DEPL COMP 3 NOEU LECT pdis TERM
trac 1 2  axes 1.0 'SIG'
trac 9  axes 1.0 'EPSHYD'
trac 3 4  axes 1.0 'FAIL'
trac 11 12  axes 1.0 'SIG'
trac 19  axes 1.0 'EPSHYD'
trac 13 14  axes 1.0 'FAIL'
trac 21 22  axes 1.0 'SIG'
trac 29  axes 1.0 'EPSHYD'
trac 23 24  axes 1.0 'FAIL'
trac 99 text axes 1.0 'DISPL. [M]'
SUIT
emi12_avi
 ECHO
 CONV WIN
RESU ALIC GARD PSCR
*
OPTI PRIN
*
SORT VISU NSTO 1
PLAY
CAME   1 EYE   5.00000E-01  4.00000E-01  6.42268E+00
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   1.08819E+01
SCEN GEOM NAVI FREE
         FACE SBAC
         POIN SPHP
     ISO  FILL FIEL ECRO 12 SCAL A14
     TEXT ISCA
     COLO PAPE
sler cam1 1       nfra 1
freq 100
go
trac offs fich bmp
     obje lect a_glass1 term   rend
ENDPLAY
FIN
```

emi_ls28_adap_maxl4_dhan.epx

```
emi_ls28 with model lsgl
$
 ECHO
! VERI
 CONV WIN
CAST 'emi_ls28.msh' modell
TRID LAGR EROS 1.0
OPTI TOLC 1e-1
DIME
  ADAP NPOI 1000000 Q4GS 400000 CL3D 400000
  ENDA
  TERM
$
GEOM
  CUB8 v1
  Q4GS a_glass1
  CL3D a_airb
TERM
$
COMP
 EPAI 0.0075 LECT a_glass1 _Q4GS TERM
 SAND    3
  FRAC 0.4 0.2 0.4
  NGPZ   2 1 2
  LECT a_glass1 _Q4GS term
   ADAP THRS ECRO 6 TMIN 0.0 TMAX 0.4 MAXL 4 LECT a_glass1 TERM
MATE
      LSGL RO 2500 YOUN 7E10 NU 0.23 CORR 16.0 REDU 0.0
           FAIL PEPR LIMI 0.0012
```

```
          LECT a_glass1 _Q4GS TERM
          laye lect 1 3 term
     VM23 RO 1100. YOUNG 3E6 NU 0.46 ELAS 3.45E9
          TRAC 1 3.45E9 1150
          LECT a_glass1 _Q4GS TERM
          laye lect 2 term
     GLIN RO 2770. YOUNG 3.5e6 NU 0.42
          LECT v1 TERM
     IMPE AIRB NODE LECT ch1 TERM CONF 1 MASS 0.09 TAUT
          LECT a_airb _CL3D TERM
LINK COUP SPLT NONE SOLV PARD
     BLOQ 123 bound TERM

ECRI FICH PVTK TFRE 5e-5 VARI ECRO CONT DEPL FEXT FINT VITE FAIL
             GROU AUTO
     FICH ALIC TEMP tfreq 1e-5
             POIN LECT pdis TERM
             ELEM LECT 4148 1628 1698 edis1 TERM
$
OPTI NOTE LOG 1
ADAP RCON DHAN
$
CALC TINI 0 TEND 10e-3
*=================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
*
RESU ALIC TEMP GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'sig_edis' CONT COMP 1 GAUZ 0 ELEM LECT 4148 TERM
COUR 2 'sig_edis' CONT COMP 2 GAUZ 0 ELEM LECT 4148 TERM
COUR 3 'sig_edis' ECRO COMP 12 GAUZ 0 ELEM LECT 4148 TERM
COUR 4 'sig_edis' ECRO COMP 9 GAUZ 0 ELEM LECT 4148 TERM
COUR 5 'sig_edis' ECRO COMP 4 GAUZ 0 ELEM LECT 4148 TERM
COUR 6 'sig_edis' ECRO COMP 5 GAUZ 0 ELEM LECT 4148 TERM
COUR 7 'sig_edis' ECRO COMP 8 GAUZ 0 ELEM LECT 4148 TERM
COUR 11 'sig_edis' CONT COMP 1 GAUZ 0 ELEM LECT 1628 TERM
COUR 12 'sig_edis' CONT COMP 2 GAUZ 0 ELEM LECT 1628 TERM
COUR 13 'sig_edis' ECRO COMP 12 GAUZ 0 ELEM LECT 1628 TERM
COUR 14 'sig_edis' ECRO COMP 9 GAUZ 0 ELEM LECT 1628 TERM
COUR 15 'sig_edis' ECRO COMP 4 GAUZ 0 ELEM LECT 1628 TERM
COUR 16 'sig_edis' ECRO COMP 5 GAUZ 0 ELEM LECT 1628 TERM
COUR 17 'sig_edis' ECRO COMP 8 GAUZ 0 ELEM LECT 1628 TERM
COUR 21 'sig_edis' CONT COMP 1 GAUZ 0 ELEM LECT 1698 TERM
COUR 22 'sig_edis' CONT COMP 2 GAUZ 0 ELEM LECT 1698 TERM
COUR 23 'sig_edis' ECRO COMP 12 GAUZ 0 ELEM LECT 1698 TERM
COUR 24 'sig_edis' ECRO COMP 9 GAUZ 0 ELEM LECT 1698 TERM
COUR 25 'sig_edis' ECRO COMP 4 GAUZ 0 ELEM LECT 1698 TERM
COUR 26 'sig_edis' ECRO COMP 5 GAUZ 0 ELEM LECT 1698 TERM
COUR 27 'sig_edis' ECRO COMP 8 GAUZ 0 ELEM LECT 1698 TERM
COUR 9 SOMME 3 5 1 6 1 7 1
COUR 19 SOMME 3 15 1 16 1 17 1
COUR 29 SOMME 3 25 1 26 1 27 1
COUR 99 'dz_pdis' DEPL COMP 3 NOEU LECT pdis TERM
trac 1 2  axes 1.0 'SIG'
trac 9  axes 1.0 'EPSHYD'
trac 3 4  axes 1.0 'FAIL'
trac 11 12  axes 1.0 'SIG'
trac 19  axes 1.0 'EPSHYD'
trac 13 14  axes 1.0 'FAIL'
trac 21 22  axes 1.0 'SIG'
trac 29  axes 1.0 'EPSHYD'
trac 23 24  axes 1.0 'FAIL'
trac 99 text axes 1.0 'DISPL. [M]'
SUIT
emi12_avi
 ECHO
 CONV WIN
RESU ALIC GARD PSCR
*
OPTI PRIN
*
SORT VISU NSTO 1
PLAY
CAME   1 EYE   5.00000E-01  4.00000E-01  6.42268E+00
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   1.08819E+01
SCEN GEOM NAVI FREE
          FACE SBAC
          POIN SPHP
     ISO  FILL FIEL ECRO 12 SCAL A14
     TEXT ISCA
     COLO PAPE
sler cam1 1        nfra 1
freq 100
go
trac offs fich bmp
     obje lect a_glass1 term   rend
ENDPLAY
FIN
```

emi_ls28_adap_maxl4_whan.epx

```
emi_ls28 with model lsgl
$
 ECHO
! VERI
 CONV WIN
CAST 'emi_ls28.msh' modell
TRID LAGR EROS 1.0
OPTI TOLC 1e-1
DIME
  ADAP NPOI 1000000 Q4GS 400000 CL3D 400000
  ENDA
  TERM
$
GEOM
  CUB8 v1
  Q4GS a_glass1
  CL3D a_airb
TERM
$
COMP
 EPAI 0.0075 LECT a_glass1 _Q4GS TERM
 SAND    3
  FRAC 0.4 0.2 0.4
  NGPZ   2 1 2
  LECT a_glass1 _Q4GS term
   ADAP THRS ECRO 6 TMIN 0.0 TMAX 0.4 MAXL 4 LECT a_glass1 TERM
MATE
      LSGL RO 2500 YOUN 7E10 NU 0.23 CORR 16.0 REDU 0.0
           FAIL PEPR LIMI 0.0012
           LECT a_glass1 _Q4GS TERM
           laye lect 1 3 term
      VM23 RO 1100. YOUNG 3E6 NU 0.46 ELAS 3.45E9
           TRAC 1 3.45E9 1150
           LECT a_glass1 _Q4GS TERM
           laye lect 2 term
      GLIN RO 2770. YOUNG 3.5e6 NU 0.42
           LECT v1 TERM
      IMPE AIRB NODE LECT ch1 TERM CONF 1 MASS 0.09 TAUT
           LECT a_airb _CL3D TERM
LINK COUP SPLT NONE SOLV PARD
     BLOQ 123 bound TERM

ECRI FICH PVTK TFRE 5e-5 VARI ECRO CONT DEPL FEXT FINT VITE FAIL
             GROU AUTO
     FICH ALIC TEMP tfreq 1e-5
             POIN LECT pdis TERM
             ELEM LECT 4148 1628 1698 edis1 TERM
$
OPTI NOTE LOG 1
ADAP RCON WHAN
$
CALC TINI 0 TEND 10e-3
*=================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
*
RESU ALIC TEMP GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'sig_edis' CONT COMP 1 GAUZ 0 ELEM LECT 4148 TERM
COUR 2 'sig_edis' CONT COMP 2 GAUZ 0 ELEM LECT 4148 TERM
COUR 3 'sig_edis' ECRO COMP 12 GAUZ 0 ELEM LECT 4148 TERM
COUR 4 'sig_edis' ECRO COMP 9 GAUZ 0 ELEM LECT 4148 TERM
COUR 5 'sig_edis' ECRO COMP 4 GAUZ 0 ELEM LECT 4148 TERM
COUR 6 'sig_edis' ECRO COMP 5 GAUZ 0 ELEM LECT 4148 TERM
COUR 7 'sig_edis' ECRO COMP 8 GAUZ 0 ELEM LECT 4148 TERM
COUR 11 'sig_edis' CONT COMP 1 GAUZ 0 ELEM LECT 1628 TERM
COUR 12 'sig_edis' CONT COMP 2 GAUZ 0 ELEM LECT 1628 TERM
COUR 13 'sig_edis' ECRO COMP 12 GAUZ 0 ELEM LECT 1628 TERM
COUR 14 'sig_edis' ECRO COMP 9 GAUZ 0 ELEM LECT 1628 TERM
COUR 15 'sig_edis' ECRO COMP 4 GAUZ 0 ELEM LECT 1628 TERM
COUR 16 'sig_edis' ECRO COMP 5 GAUZ 0 ELEM LECT 1628 TERM
COUR 17 'sig_edis' ECRO COMP 8 GAUZ 0 ELEM LECT 1628 TERM
COUR 21 'sig_edis' CONT COMP 1 GAUZ 0 ELEM LECT 1698 TERM
COUR 22 'sig_edis' CONT COMP 2 GAUZ 0 ELEM LECT 1698 TERM
COUR 23 'sig_edis' ECRO COMP 12 GAUZ 0 ELEM LECT 1698 TERM
COUR 24 'sig_edis' ECRO COMP 9 GAUZ 0 ELEM LECT 1698 TERM
COUR 25 'sig_edis' ECRO COMP 4 GAUZ 0 ELEM LECT 1698 TERM
COUR 26 'sig_edis' ECRO COMP 5 GAUZ 0 ELEM LECT 1698 TERM
COUR 27 'sig_edis' ECRO COMP 8 GAUZ 0 ELEM LECT 1698 TERM
COUR 9 SOMME 3 5 1 6 1 7 1
COUR 19 SOMME 3 15 1 16 1 17 1
COUR 29 SOMME 3 25 1 26 1 27 1
COUR 99 'dz_pdis' DEPL COMP 3 NOEU LECT pdis TERM
trac 1 2  axes 1.0 'SIG'
trac 9  axes 1.0 'EPSHYD'
trac 3 4  axes 1.0 'FAIL'
trac 11 12  axes 1.0 'SIG'
trac 19  axes 1.0 'EPSHYD'
trac 13 14  axes 1.0 'FAIL'
trac 21 22  axes 1.0 'SIG'
trac 29  axes 1.0 'EPSHYD'
trac 23 24  axes 1.0 'FAIL'
trac 99 text axes 1.0 'DISPL. [M]'
SUIT
emi12_avi
 ECHO
 CONV WIN
RESU ALIC GARD PSCR
*
OPTI PRIN
*
SORT VISU NSTO 1
PLAY
CAME   1 EYE   5.00000E-01  4.00000E-01  6.42268E+00
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   1.08819E+01
SCEN GEOM NAVI FREE
          FACE SBAC
          POIN SPHP
     ISO  FILL FIEL ECRO 12 SCAL A14
     TEXT ISCA
     COLO PAPE
sler cam1 1        nfra 1
freq 100
go
trac offs fich bmp
     obje lect a_glass1 term   rend
ENDPLAY
FIN
```

plat00.dgibi

```
opti echo 1;
opti dime 3 elem cub8;
opti sauv form 'plat00.msh';
opti trac psc ftra 'plat00_mesh.ps';
*
camD = 100.0;
oelz = 0 0 camD;
oel = camD camD camD;
oelm = (0 - camD) (0 + camD) (0 - camD);
tol = 1.E-3;
Elst = 0.025;
dx = 0.4;
dy = 0.4;
p1 = 0 0 0;
p2 = p1 PLUS (dx 0 0);
nxf = ENTI ((dx + 0.0001) / (Elst));
nyf = ENTI ((dy + 0.0001) / (Elst));
list nxf;
list nyf;
c1 = p1 D nxf p2;
smesh = c1 TRAN nyf (0 dy 0);
pres = smesh PLUS (0 0 0);
dz = 0.05;
nzf = ENTI ((dz + 0.0001) / (Elst));
vmesh = smesh VOLU TRAN nzf (0 0 (0+dz));
*
OUBL c1;
LIST (NBEL vmesh);
mesh = vmesh ET pres;
*
elim tol mesh;
TRAC oel CACH QUAL ( mesh );
TRAC oelm CACH QUAL ( mesh );
TASS mesh NOOP;
SAUV FORM mesh;
*
fin;
```

plat00.epx

```
PLAT00
ECHO
!CONV WIN
CAST mesh
EROS 0.0
TRID LAGR
DIME
  ADAP NPOI 50000 CUBE 30000 CL3Q 4000
  ENDA
*  DEBR
TERM
GEOM CUBE vmesh CL3Q pres TERM
COMP GROU 13 'Load' LECT vmesh TERM
                   COND YB LT 0.35
                   COND YB GT 0.05
                   COND XB LT 0.35
                   COND XB GT 0.05
            'Fri1' LECT vmesh TERM
                   COND YB GT 0.35
            'Fri2' LECT vmesh TERM
                   COND YB LT 0.05
            'Fri3' LECT vmesh TERM
                   COND XB GT 0.35
            'Fri4' LECT vmesh TERM
                   COND XB LT 0.05
            'PresC1' LECT pres TERM
                   COND NEAR POIN 0.2 0.2 0.0
            'PresC2' LECT pres TERM
                   COND NEAR POIN 0.2625 0.2 0.0
            'PresC3' LECT pres TERM
                   COND NEAR POIN 0.2 0.2625 0.0
            'PresB1' LECT pres TERM
                   COND NEAR POIN 0.2 0.375 0.0
            'PresB2' LECT pres TERM
                   COND NEAR POIN 0.2625 0.375 0.0
            'PresB3' LECT pres TERM
                   COND NEAR POIN 0.325 0.375 0.0
            'CenEl' LECT vmesh TERM
                   COND NEAR POIN 0.2 0.2 0.0
            'EROA' LECT vmesh TERM
                   COND SPHE XC 0.2 YC 0.2 ZC 0.025 R 0.12
     COUL ROUG LECT vmesh TERM
      NGRO 5 'fix1' LECT vmesh TERM COND Y GT 0.35
             'fix2' LECT vmesh TERM COND Y LT 0.045
             'fix3' LECT vmesh TERM COND X GT 0.35
             'fix4' LECT vmesh TERM COND X LT 0.045
             'cen' LECT vmesh TERM COND NEAR POIN 0.2 0.2 0.0
     FONC 1 TABL 5 0 0.2e5
                   1.e-3 2.5e6
                   15e-3 4.5e6
                   90e-3 1e5
                   500e-3 1.e5
 ADAP THRS ECRO 13 TMIN 0.2 TMAX 0.6 MAXL 4
          LECT vmesh TERM
MATE
 DPDC RO 2360 YOUN 40.1E+9 NU 0.2
      FC 44.82E+6 DAGG 16.0E-3  VERS 8 !EFVI
      EROD ENDT 0.75 ENDC 0.75 DVOL 0.3
      LECT vmesh _cube TERM
      IMPE PIMP RO 2360 PRES -4.5 PREF 1.003E5 FONC 1
      LECT pres _cl3q TERM
LINK COUP SPLT NONE
     BLOQ 123 LECT fix1 fix2 fix3 fix4 TERM
ECRI VITE CONT ECRO TFRE 0.2E-3
        POIN LECT 1 TERM
        ELEM LECT 1 TERM
     FICH SPLI ALIC TFRE 0.1E-3
OPTI NOTE
     CSTA 0.75
     ADAP RCON STAT
     LOG 1
     LNKS STAT DIAG
CALC TINI 0 TEND 1.0E-3
FIN
```

plat00a.epx

```
Post treatment (visualization from alice file)
ECHO
 CONV WIN
RESU SPLI ALIC 'plat00.ali' GARD PSCR
COMP COUL VERT LECT vmesh TERM
OPTI PRIN
SORT VISU NSTO 1
*=========================================================================
PLAY
CAME   1 EYE   2.00000E-01  2.00000E-01  1.44794E+00 ! Front view
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   2 EYE  -7.52864E-01  6.82277E-01  9.64262E-01 ! Front view, tilted
!        Q     9.09446E-01 -1.64981E-01 -3.78132E-01 -5.20183E-02
         VIEW  6.70618E-01 -3.39422E-01 -6.59594E-01
         RIGH  7.08620E-01  3.01537E-02  7.04946E-01
         UP    2.19385E-01  9.40151E-01 -2.60743E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   3 EYE  -6.58241E-01  6.85968E-01 -9.95751E-01 ! Back view, tilted
!        Q     3.36824E-01 -5.93912E-02 -9.25417E-01 -1.63176E-01
         VIEW  6.04023E-01 -3.42020E-01  7.19846E-01
         RIGH -7.66044E-01 -1.38778E-17  6.42788E-01
         UP    2.19846E-01  9.39693E-01  2.62003E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
SCEN GEOM NAVI FREE
     COLO PAPE
     LIMA ON
SLER CAM1 3 NFRA 1
FREQ 1
TRAC OFFS FICH AVI NOCL NFTO 11 FPS 10 KFRE 4 COMP -1
     OBJE LECT vmesh TERM NFAI REND
GOTR LOOP 9 OFFS FICH AVI CONT NOCL
     OBJE LECT vmesh TERM NFAI REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT vmesh TERM NFAI REND
ENDPLAY
*=========================================================================
FIN
```

plat00ab.epx

```
Post treatment (visualization from alice file)
ECHO
 CONV WIN
RESU SPLI ALIC 'plat00.ali' GARD PSCR
COMP COUL VERT LECT vmesh TERM
OPTI PRIN
SORT VISU NSTO 11
*=========================================================================
PLAY
CAME   1 EYE   2.00000E-01  2.00000E-01  1.44794E+00 ! Front view
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   2 EYE  -7.52864E-01  6.82277E-01  9.64262E-01 ! Front view, tilted
!        Q     9.09446E-01 -1.64981E-01 -3.78132E-01 -5.20183E-02
         VIEW  6.70618E-01 -3.39422E-01 -6.59594E-01
         RIGH  7.08620E-01  3.01537E-02  7.04946E-01
         UP    2.19385E-01  9.40151E-01 -2.60743E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   3 EYE  -6.58241E-01  6.85968E-01 -9.95751E-01 ! Back view, tilted
!        Q     3.36824E-01 -5.93912E-02 -9.25417E-01 -1.63176E-01
         VIEW  6.04023E-01 -3.42020E-01  7.19846E-01
         RIGH -7.66044E-01 -1.38778E-17  6.42788E-01
         UP    2.19846E-01  9.39693E-01  2.62003E-01
```

```
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
SCEN GEOM NAVI FREE
     COLO PAPE
     LIMA ON
SLER CAM1 1 NFRA 1
TRAC OFFS FICH BMP
     OBJE LECT vmesh TERM NFAI REND
SLER CAM1 2 NFRA 1
TRAC OFFS FICH BMP
     OBJE LECT vmesh TERM NFAI REND
SLER CAM1 3 NFRA 1
TRAC OFFS FICH BMP
     OBJE LECT vmesh TERM NFAI REND
ENDPLAY
*========================================================================
FIN
```

plat00d.epx

```
Post treatment (visualization from alice file)
ECHO
 CONV WIN
RESU SPLI ALIC 'plat00.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*========================================================================
PLAY
CAME   1 EYE   2.00000E-01  2.00000E-01  1.44794E+00 ! Front view
!        Q      1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   2 EYE  -7.52864E-01  6.82277E-01  9.64262E-01 ! Front view, tilted
!        Q      9.09446E-01 -1.64981E-01 -3.78132E-01 -5.20183E-02
         VIEW  6.70618E-01 -3.39422E-01 -6.59594E-01
         RIGH  7.08620E-01  3.01537E-02  7.04946E-01
         UP    2.19385E-01  9.40151E-01 -2.60743E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   3 EYE  -6.58241E-01  6.85968E-01 -9.95751E-01 ! Back view, tilted
!        Q      3.36824E-01 -5.93912E-02 -9.25417E-01 -1.63176E-01
         VIEW  6.04023E-01 -3.42020E-01  7.19846E-01
         RIGH -7.66044E-01 -1.38778E-17  6.42788E-01
         UP    2.19846E-01  9.39693E-01  2.62003E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
SCEN GEOM NAVI FREE
     ISO  FELE FIEL ECRO 13 SCAL USER PROG 0.05 PAS 0.05 0.70 TERM
          SUPP LECT vmesh TERM
     TEXT ISCA
     COLO PAPE
     LIMA ON
SLER CAM1 3 NFRA 1
FREQ 1
TRAC OFFS FICH AVI NOCL NFTO 11 FPS 10 KFRE 4 COMP -1
     OBJE LECT vmesh TERM NFAI REND
GOTR LOOP 9 OFFS FICH AVI CONT NOCL
     OBJE LECT vmesh TERM NFAI REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT vmesh TERM NFAI REND
ENDPLAY
*========================================================================
FIN
```

plat00db.epx

```
Post treatment (visualization from alice file)
ECHO
 CONV WIN
RESU SPLI ALIC 'plat00.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 11
*========================================================================
PLAY
CAME   1 EYE   2.00000E-01  2.00000E-01  1.44794E+00 ! Front view
!        Q      1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   2 EYE  -7.52864E-01  6.82277E-01  9.64262E-01 ! Front view, tilted
!        Q      9.09446E-01 -1.64981E-01 -3.78132E-01 -5.20183E-02
         VIEW  6.70618E-01 -3.39422E-01 -6.59594E-01
         RIGH  7.08620E-01  3.01537E-02  7.04946E-01
         UP    2.19385E-01  9.40151E-01 -2.60743E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   3 EYE  -6.58241E-01  6.85968E-01 -9.95751E-01 ! Back view, tilted
!        Q      3.36824E-01 -5.93912E-02 -9.25417E-01 -1.63176E-01
         VIEW  6.04023E-01 -3.42020E-01  7.19846E-01
         RIGH -7.66044E-01 -1.38778E-17  6.42788E-01
         UP    2.19846E-01  9.39693E-01  2.62003E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
SCEN GEOM NAVI FREE
     ISO  FELE FIEL ECRO 13 SCAL USER PROG 0.05 PAS 0.05 0.70 TERM
          SUPP LECT vmesh TERM
     TEXT ISCA
     COLO PAPE
     LIMA ON
SLER CAM1 1 NFRA 1
TRAC OFFS FICH BMP
     OBJE LECT vmesh TERM NFAI REND
SLER CAM1 2 NFRA 1
TRAC OFFS FICH BMP
     OBJE LECT vmesh TERM NFAI REND
SLER CAM1 3 NFRA 1
TRAC OFFS FICH BMP
     OBJE LECT vmesh TERM NFAI REND
ENDPLAY
*========================================================================
FIN
```

plat01.dgibi

```
opti echo 1;
opti dime 3 elem cub8;
opti sauv form 'plat01.msh';
opti trac psc ftra 'plat01_mesh.ps';
*
camD = 100.0;
oelz = 0 0 camD;
oel = camD camD camD;
oelm = (0 - camD) (0 + camD) (0 - camD);
tol = 1.E-3;
Elst = 0.025;
dx = 0.4;
dy = 0.4;
p1 = 0 0 0;
p2 = p1 PLUS (dx 0 0);
nxf = ENTI ((dx + 0.0001) / (Elst));
nyf = ENTI ((dy + 0.0001) / (Elst));
list nxf;
list nyf;
c1 = p1 D nxf p2;
smesh = c1 TRAN nyf (0 dy 0);
pres = smesh PLUS (0 0 0);
dz = 0.05;
nzf = ENTI ((dz + 0.0001) / (Elst));
vmesh = smesh VOLU TRAN nzf (0 0 (0+dz));
*
OUBL c1;
LIST (NBEL vmesh);
mesh = vmesh ET pres;
*
elim tol mesh;
TRAC oel CACH QUAL ( mesh );
TRAC oelm CACH QUAL ( mesh );
TASS mesh NOOP;
SAUV FORM mesh;
*
fin;
```

plat01.epx

```
PLAT01
ECHO
 CONV WIN
CAST mesh
EROS 0.0
TRID LAGR
DIME
  ADAP NPOI 50000 CUBE 30000 CL3Q 4000
  ENDA
*  DEBR
TERM
GEOM CUBE vmesh CL3Q pres TERM
COMP GROU 13 'Load' LECT vmesh TERM
                   COND YB LT 0.35
                   COND YB GT 0.05
                   COND XB LT 0.35
                   COND XB GT 0.05
            'Fri1' LECT vmesh TERM
                   COND YB GT 0.35
            'Fri2' LECT vmesh TERM
                   COND YB LT 0.05
            'Fri3' LECT vmesh TERM
```

```
                   COND XB GT 0.35
            'Fri4' LECT vmesh TERM
                   COND XB LT 0.05
            'PresC1' LECT pres TERM
                   COND NEAR POIN 0.2 0.2 0.0
            'PresC2' LECT pres TERM
                   COND NEAR POIN 0.2625 0.2 0.0
            'PresC3' LECT pres TERM
                   COND NEAR POIN 0.2 0.2625 0.0
            'PresB1' LECT pres TERM
                   COND NEAR POIN 0.2 0.375 0.0
            'PresB2' LECT pres TERM
                   COND NEAR POIN 0.2625 0.375 0.0
            'PresB3' LECT pres TERM
                   COND NEAR POIN 0.325 0.375 0.0
            'CenEl' LECT vmesh TERM
                   COND NEAR POIN 0.2 0.2 0.0
            'EROA' LECT vmesh TERM
                   COND SPHE XC 0.2 YC 0.2 ZC 0.025 R 0.12
     COUL ROUG LECT vmesh TERM
      NGRO 5 'fix1' LECT vmesh TERM COND Y GT 0.35
             'fix2' LECT vmesh TERM COND Y LT 0.045
             'fix3' LECT vmesh TERM COND X GT 0.35
             'fix4' LECT vmesh TERM COND X LT 0.045
             'cen' LECT vmesh TERM COND NEAR POIN 0.2 0.2 0.0
     FONC 1 TABL 5 0 0.2e5
                   1.e-3 2.5e6
                   15e-3 4.5e6
                   90e-3 1e5
                   500e-3 1.e5
 ADAP THRS ECRO 13 TMIN 0.2 TMAX 0.6 MAXL 4
           LECT vmesh TERM
MATE
 DPDC RO 2360 YOUN 40.1E+9 NU 0.2
      FC 44.82E+6 DAGG 16.0E-3  VERS 8 !EFVI
      EROD ENDT 0.75 ENDC 0.75 DVOL 0.3
      LECT vmesh _cube TERM
      IMPE PIMP RO 2360 PRES -4.5 PREF 1.003E5 FONC 1
      LECT pres _cl3q TERM
LINK COUP SPLT NONE
     BLOQ 123 LECT fix1 fix2 fix3 fix4 TERM
ECRI VITE CONT ECRO TFRE 0.2E-3
         POIN LECT 1 TERM
         ELEM LECT 1 TERM
     FICH SPLI ALIC TFRE 0.1E-3
OPTI NOTE
     CSTA 0.75
     ADAP RCON STAT DHAN
     LOG 1
     LNKS STAT DIAG
CALC TINI 0 TEND 1.5E-3
FIN
```

plat02.dgibi

```
opti echo 1;
opti dime 3 elem cub8;
opti sauv form 'plat02.msh';
opti trac psc ftra 'plat02_mesh.ps';
*
camD = 100.0;
oelz = 0 0 camD;
oel = camD camD camD;
oelm = (0 - camD) (0 + camD) (0 - camD);
tol = 1.E-3;
Elst = 0.025;
dx = 0.4;
dy = 0.4;
p1 = 0 0 0;
p2 = p1 PLUS (dx 0 0);
nxf = ENTI ((dx + 0.0001) / (Elst));
nyf = ENTI ((dy + 0.0001) / (Elst));
list nxf;
list nyf;
c1 = p1 D nxf p2;
smesh = c1 TRAN nyf (0 dy 0);
pres = smesh PLUS (0 0 0);
dz = 0.05;
nzf = ENTI ((dz + 0.0001) / (Elst));
vmesh = smesh VOLU TRAN nzf (0 0 (0+dz));
*
OUBL c1;
LIST (NBEL vmesh);
mesh = vmesh ET pres;
*
elim tol mesh;
TRAC oel CACH QUAL ( mesh );
TRAC oelm CACH QUAL ( mesh );
TASS mesh NOOP;
SAUV FORM mesh;
*
fin;
```

plat02.epx

```
PLAT02
ECHO
!CONV WIN
CAST mesh
EROS 0.0
TRID LAGR
DIME
  ADAP NPOI 41522 CUBE 32680 CL3Q 2720
  ENDA
*  DEBR
TERM
GEOM CUBE vmesh CL3Q pres TERM
COMP GROU 13 'Load' LECT vmesh TERM
                   COND YB LT 0.35
                   COND YB GT 0.05
                   COND XB LT 0.35
                   COND XB GT 0.05
            'Fri1' LECT vmesh TERM
                   COND YB GT 0.35
            'Fri2' LECT vmesh TERM
                   COND YB LT 0.05
            'Fri3' LECT vmesh TERM
                   COND XB GT 0.35
            'Fri4' LECT vmesh TERM
                   COND XB LT 0.05
            'PresC1' LECT pres TERM
                   COND NEAR POIN 0.2 0.2 0.0
            'PresC2' LECT pres TERM
                   COND NEAR POIN 0.2625 0.2 0.0
            'PresC3' LECT pres TERM
                   COND NEAR POIN 0.2 0.2625 0.0
            'PresB1' LECT pres TERM
                   COND NEAR POIN 0.2 0.375 0.0
            'PresB2' LECT pres TERM
                   COND NEAR POIN 0.2625 0.375 0.0
            'PresB3' LECT pres TERM
                   COND NEAR POIN 0.325 0.375 0.0
            'CenEl' LECT vmesh TERM
                   COND NEAR POIN 0.2 0.2 0.0
            'EROA' LECT vmesh TERM
                   COND SPHE XC 0.2 YC 0.2 ZC 0.025 R 0.12
     COUL ROUG LECT vmesh TERM
      NGRO 5 'fix1' LECT vmesh TERM COND Y GT 0.35
             'fix2' LECT vmesh TERM COND Y LT 0.045
             'fix3' LECT vmesh TERM COND X GT 0.35
             'fix4' LECT vmesh TERM COND X LT 0.045
             'cen' LECT vmesh TERM COND NEAR POIN 0.2 0.2 0.0
     FONC 1 TABL 5 0 0.2e5
                   1.e-3 2.5e6
                   15e-3 4.5e6
                   90e-3 1e5
                   500e-3 1.e5
 ADAP THRS ECRO 13 TMIN 0.2 TMAX 0.6 MAXL 4
           LECT vmesh TERM
MATE
 DPDC RO 2360 YOUN 40.1E+9 NU 0.2
      FC 44.82E+6 DAGG 16.0E-3  VERS 8 !EFVI
      EROD ENDT 0.75 ENDC 0.75 DVOL 0.3
      LECT vmesh _cube TERM
      IMPE PIMP RO 2360 PRES -4.5 PREF 1.003E5 FONC 1
      LECT pres _cl3q TERM
LINK COUP SPLT NONE
     BLOQ 123 LECT fix1 fix2 fix3 fix4 TERM
ECRI VITE CONT ECRO TFRE 0.2E-3
         POIN LECT 1 TERM
         ELEM LECT 1 TERM
     FICH SPLI ALIC TFRE 0.1E-3
OPTI NOTE
     CSTA 0.75
     ADAP RCON STAT WHAN
     LOG 1
     LNKS STAT DIAG
CALC TINI 0 TEND 1.0E-3
FIN
```

plat02a.epx

```
Post treatment (visualization from alice file)
ECHO
 CONV WIN
RESU SPLI ALIC 'plat02.ali' GARD PSCR
COMP COUL VERT LECT vmesh TERM
OPTI PRIN
SORT VISU NSTO 1
*=======================================================================
PLAY
CAME   1 EYE   2.00000E-01  2.00000E-01  1.44794E+00 ! Front view
!         Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   2 EYE  -7.52864E-01  6.82277E-01  9.64262E-01 ! Front view, tilted
!         Q     9.09446E-01 -1.64981E-01 -3.78132E-01 -5.20183E-02
         VIEW  6.70618E-01 -3.39422E-01 -6.59594E-01
         RIGH  7.08620E-01  3.01537E-02  7.04946E-01
         UP    2.19385E-01  9.40151E-01 -2.60743E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   3 EYE  -6.58241E-01  6.85968E-01 -9.95751E-01 ! Back view, tilted
!         Q     3.36824E-01 -5.93912E-02 -9.25417E-01 -1.63176E-01
         VIEW  6.04023E-01 -3.42020E-01  7.19846E-01
         RIGH -7.66044E-01 -1.38778E-17  6.42788E-01
         UP    2.19846E-01  9.39693E-01  2.62003E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
SCEN GEOM NAVI FREE
     COLO PAPE
     LIMA ON
SLER CAM1 3 NFRA 1
FREQ 1
TRAC OFFS FICH AVI NOCL NFTO 11 FPS 10 KFRE 4 COMP -1
     OBJE LECT vmesh TERM NFAI REND
```

```
GOTR LOOP 9 OFFS FICH AVI CONT NOCL
     OBJE LECT vmesh TERM NFAI REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT vmesh TERM NFAI REND
ENDPLAY
*=======================================================================
FIN
```

plat02ab.epx

```
Post treatment (visualization from alice file)
ECHO
 CONV WIN
RESU SPLI ALIC 'plat02.ali' GARD PSCR
COMP COUL VERT LECT vmesh TERM
OPTI PRIN
SORT VISU NSTO 11
*=======================================================================
PLAY
CAME   1 EYE   2.00000E-01  2.00000E-01  1.44794E+00 ! Front view
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   2 EYE  -7.52864E-01  6.82277E-01  9.64262E-01 ! Front view, tilted
!        Q     9.09446E-01 -1.64981E-01 -3.78132E-01 -5.20183E-02
         VIEW  6.70618E-01 -3.39422E-01 -6.59594E-01
         RIGH  7.08620E-01  3.01537E-02  7.04946E-01
         UP    2.19385E-01  9.40151E-01 -2.60743E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   3 EYE  -6.58241E-01  6.85968E-01 -9.95751E-01 ! Back view, tilted
!        Q     3.36824E-01 -5.93912E-02 -9.25417E-01 -1.63176E-01
         VIEW  6.04023E-01 -3.42020E-01  7.19846E-01
         RIGH -7.66044E-01 -1.38778E-17  6.42788E-01
         UP    2.19846E-01  9.39693E-01  2.62003E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
SCEN GEOM NAVI FREE
     COLO PAPE
     LIMA ON
SLER CAM1 1 NFRA 1
TRAC OFFS FICH BMP
     OBJE LECT vmesh TERM NFAI REND
SLER CAM1 2 NFRA 1
TRAC OFFS FICH BMP
     OBJE LECT vmesh TERM NFAI REND
SLER CAM1 3 NFRA 1
TRAC OFFS FICH BMP
     OBJE LECT vmesh TERM NFAI REND
ENDPLAY
*=======================================================================
FIN
```

plat02d.epx

```
Post treatment (visualization from alice file)
ECHO
 CONV WIN
RESU SPLI ALIC 'plat02.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=======================================================================
PLAY
CAME   1 EYE   2.00000E-01  2.00000E-01  1.44794E+00 ! Front view
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   2 EYE  -7.52864E-01  6.82277E-01  9.64262E-01 ! Front view, tilted
!        Q     9.09446E-01 -1.64981E-01 -3.78132E-01 -5.20183E-02
         VIEW  6.70618E-01 -3.39422E-01 -6.59594E-01
         RIGH  7.08620E-01  3.01537E-02  7.04946E-01
         UP    2.19385E-01  9.40151E-01 -2.60743E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   3 EYE  -6.58241E-01  6.85968E-01 -9.95751E-01 ! Back view, tilted
!        Q     3.36824E-01 -5.93912E-02 -9.25417E-01 -1.63176E-01
         VIEW  6.04023E-01 -3.42020E-01  7.19846E-01
         RIGH -7.66044E-01 -1.38778E-17  6.42788E-01
         UP    2.19846E-01  9.39693E-01  2.62003E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
SCEN GEOM NAVI FREE
     ISO  FELE FIEL ECRO 13 SCAL USER PROG 0.05 PAS 0.05 0.70 TERM
          SUPP LECT vmesh TERM
     TEXT ISCA
     COLO PAPE
     LIMA ON
SLER CAM1 3 NFRA 1
FREQ 1
TRAC OFFS FICH AVI NOCL NFTO 11 FPS 10 KFRE 4 COMP -1
     OBJE LECT vmesh TERM NFAI REND
GOTR LOOP 9 OFFS FICH AVI CONT NOCL
     OBJE LECT vmesh TERM NFAI REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT vmesh TERM NFAI REND
ENDPLAY
*=======================================================================
FIN
```

plat02db.epx

```
Post treatment (visualization from alice file)
ECHO
 CONV WIN
RESU SPLI ALIC 'plat02.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 11
*=======================================================================
PLAY
CAME   1 EYE   2.00000E-01  2.00000E-01  1.44794E+00 ! Front view
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   2 EYE  -7.52864E-01  6.82277E-01  9.64262E-01 ! Front view, tilted
!        Q     9.09446E-01 -1.64981E-01 -3.78132E-01 -5.20183E-02
         VIEW  6.70618E-01 -3.39422E-01 -6.59594E-01
         RIGH  7.08620E-01  3.01537E-02  7.04946E-01
         UP    2.19385E-01  9.40151E-01 -2.60743E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   3 EYE  -6.58241E-01  6.85968E-01 -9.95751E-01 ! Back view, tilted
!        Q     3.36824E-01 -5.93912E-02 -9.25417E-01 -1.63176E-01
         VIEW  6.04023E-01 -3.42020E-01  7.19846E-01
         RIGH -7.66044E-01 -1.38778E-17  6.42788E-01
         UP    2.19846E-01  9.39693E-01  2.62003E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
SCEN GEOM NAVI FREE
     ISO  FELE FIEL ECRO 13 SCAL USER PROG 0.05 PAS 0.05 0.70 TERM
          SUPP LECT vmesh TERM
     TEXT ISCA
     COLO PAPE
     LIMA ON
SLER CAM1 1 NFRA 1
TRAC OFFS FICH BMP
     OBJE LECT vmesh TERM NFAI REND
SLER CAM1 2 NFRA 1
TRAC OFFS FICH BMP
     OBJE LECT vmesh TERM NFAI REND
SLER CAM1 3 NFRA 1
TRAC OFFS FICH BMP
     OBJE LECT vmesh TERM NFAI REND
ENDPLAY
*=======================================================================
FIN
```

plat03.dgibi

```
opti echo 1;
opti dime 3 elem cub8;
opti sauv form 'plat03.msh';
opti trac psc ftra 'plat03_mesh.ps';
*
camD = 100.0;
oelz = 0 0 camD;
oel = camD camD camD;
oelm = (0 - camD) (0 + camD) (0 - camD);
tol = 1.E-3;
Elst = 0.025;
dx = 0.4;
dy = 0.4;
```

```
p1 = 0 0 0;
p2 = p1 PLUS (dx 0 0);
nxf = ENTI ((dx + 0.0001) / (Elst));
nyf = ENTI ((dy + 0.0001) / (Elst));
list nxf;
list nyf;
c1 = p1 D nxf p2;
smesh = c1 TRAN nyf (0 dy 0);
pres = smesh PLUS (0 0 0);
dz = 0.05;
nzf = ENTI ((dz + 0.0001) / (Elst));
vmesh = smesh VOLU TRAN nzf (0 0 (0+dz));
*
OUBL c1;
LIST (NBEL vmesh);
mesh = vmesh ET pres;
*
elim tol mesh;
TRAC oel CACH QUAL ( mesh );
TRAC oelm CACH QUAL ( mesh );
TASS mesh NOOP;
SAUV FORM mesh;
*
fin;
```

plat03.epx

```
PLAT03
ECHO
!CONV WIN
CAST mesh
EROS 0.0
TRID LAGR
DIME
  ADAP NPOI 50000 CUBE 30000 CL3Q 4000
  ENDA
*  DEBR
TERM
GEOM CUBE vmesh CL3Q pres TERM
COMP GROU 13 'Load' LECT vmesh TERM
                   COND YB LT 0.35
                   COND YB GT 0.05
                   COND XB LT 0.35
                   COND XB GT 0.05
            'Fri1' LECT vmesh TERM
                   COND YB GT 0.35
            'Fri2' LECT vmesh TERM
                   COND YB LT 0.05
            'Fri3' LECT vmesh TERM
                   COND XB GT 0.35
            'Fri4' LECT vmesh TERM
                   COND XB LT 0.05
            'PresC1' LECT pres TERM
                   COND NEAR POIN 0.2 0.2 0.0
            'PresC2' LECT pres TERM
                   COND NEAR POIN 0.2625 0.2 0.0
            'PresC3' LECT pres TERM
                   COND NEAR POIN 0.2 0.2625 0.0
            'PresB1' LECT pres TERM
                   COND NEAR POIN 0.2 0.375 0.0
            'PresB2' LECT pres TERM
                   COND NEAR POIN 0.2625 0.375 0.0
            'PresB3' LECT pres TERM
                   COND NEAR POIN 0.325 0.375 0.0
            'CenEl' LECT vmesh TERM
                   COND NEAR POIN 0.2 0.2 0.0
            'EROA' LECT vmesh TERM
                   COND SPHE XC 0.2 YC 0.2 ZC 0.025 R 0.12
     COUL ROUG LECT vmesh TERM
      NGRO 5 'fix1' LECT vmesh TERM COND Y GT 0.35
             'fix2' LECT vmesh TERM COND Y LT 0.045
             'fix3' LECT vmesh TERM COND X GT 0.35
             'fix4' LECT vmesh TERM COND X LT 0.045
             'cen' LECT vmesh TERM COND NEAR POIN 0.2 0.2 0.0
     FONC 1 TABL 5 0 0.2e5
                   1.e-3 2.5e6
                   15e-3 4.5e6
                   90e-3 1e5
                   500e-3 1.e5
 ADAP THRS ECRO 13 TMIN 0.2 TMAX 0.6 MAXL 4
           LECT vmesh TERM
MATE
 DPDC RO 2360 YOUN 40.1E+9 NU 0.2
      FC 44.82E+6 DAGG 16.0E-3  VERS 8 !EFVI
      EROD ENDT 0.75 ENDC 0.75 DVOL 0.3
      LECT vmesh _cube TERM
      IMPE PIMP RO 2360 PRES -4.5 PREF 1.003E5 FONC 1
      LECT pres _cl3q TERM
LINK COUP SPLT NONE SOLV PARD
     BLOQ 123 LECT fix1 fix2 fix3 fix4 TERM
ECRI VITE CONT ECRO TFRE 0.2E-3
         POIN LECT 1 TERM
         ELEM LECT 1 TERM
     FICH SPLI ALIC TFRE 0.1E-3
OPTI NOTE
     CSTA 0.75
     ADAP RCON STAT
     LOG 1
     LNKS STAT DIAG
CALC TINI 0 TEND 1.0E-3
FIN
```

plat03a.epx

```
Post treatment (visualization from alice file)
ECHO
 CONV WIN
RESU SPLI ALIC 'plat03.ali' GARD PSCR
COMP COUL VERT LECT vmesh TERM
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   2.00000E-01  2.00000E-01  1.44794E+00 ! Front view
!         Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
          VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
          RIGH  1.00000E+00  0.00000E+00  0.00000E+00
          UP    0.00000E+00  1.00000E+00  0.00000E+00
          FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   2 EYE  -7.52864E-01  6.82277E-01  9.64262E-01 ! Front view, tilted
!         Q     9.09446E-01 -1.64981E-01 -3.78132E-01 -5.20183E-02
          VIEW  6.70618E-01 -3.39422E-01 -6.59594E-01
          RIGH  7.08620E-01  3.01537E-02  7.04946E-01
          UP    2.19385E-01  9.40151E-01 -2.60743E-01
          FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   3 EYE  -6.58241E-01  6.85968E-01 -9.95751E-01 ! Back view, tilted
!         Q     3.36824E-01 -5.93912E-02 -9.25417E-01 -1.63176E-01
          VIEW  6.04023E-01 -3.42020E-01  7.19846E-01
          RIGH -7.66044E-01 -1.38778E-17  6.42788E-01
          UP    2.19846E-01  9.39693E-01  2.62003E-01
          FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
SCEN GEOM NAVI FREE
     COLO PAPE
     LIMA ON
SLER CAM1 3 NFRA 1
FREQ 1
TRAC OFFS FICH AVI NOCL NFTO 11 FPS 10 KFRE 4 COMP -1
     OBJE LECT vmesh TERM NFAI REND
GOTR LOOP 9 OFFS FICH AVI CONT NOCL
     OBJE LECT vmesh TERM NFAI REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT vmesh TERM NFAI REND
ENDPLAY
*=====================================================================
FIN
```

plat03ab.epx

```
Post treatment (visualization from alice file)
ECHO
 CONV WIN
RESU SPLI ALIC 'plat03.ali' GARD PSCR
COMP COUL VERT LECT vmesh TERM
OPTI PRIN
SORT VISU NSTO 11
*=====================================================================
PLAY
CAME   1 EYE   2.00000E-01  2.00000E-01  1.44794E+00 ! Front view
!         Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
          VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
          RIGH  1.00000E+00  0.00000E+00  0.00000E+00
          UP    0.00000E+00  1.00000E+00  0.00000E+00
          FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   2 EYE  -7.52864E-01  6.82277E-01  9.64262E-01 ! Front view, tilted
!         Q     9.09446E-01 -1.64981E-01 -3.78132E-01 -5.20183E-02
          VIEW  6.70618E-01 -3.39422E-01 -6.59594E-01
          RIGH  7.08620E-01  3.01537E-02  7.04946E-01
          UP    2.19385E-01  9.40151E-01 -2.60743E-01
          FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   3 EYE  -6.58241E-01  6.85968E-01 -9.95751E-01 ! Back view, tilted
!         Q     3.36824E-01 -5.93912E-02 -9.25417E-01 -1.63176E-01
          VIEW  6.04023E-01 -3.42020E-01  7.19846E-01
          RIGH -7.66044E-01 -1.38778E-17  6.42788E-01
          UP    2.19846E-01  9.39693E-01  2.62003E-01
          FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
SCEN GEOM NAVI FREE
     COLO PAPE
     LIMA ON
SLER CAM1 1 NFRA 1
TRAC OFFS FICH BMP
     OBJE LECT vmesh TERM NFAI REND
SLER CAM1 2 NFRA 1
TRAC OFFS FICH BMP
     OBJE LECT vmesh TERM NFAI REND
```

```
SLER CAM1 3 NFRA 1
TRAC OFFS FICH BMP
     OBJE LECT vmesh TERM NFAI REND
ENDPLAY
*========================================================================
FIN
```

plat03d.epx

```
Post treatment (visualization from alice file)
ECHO
 CONV WIN
RESU SPLI ALIC 'plat03.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*========================================================================
PLAY
CAME   1 EYE   2.00000E-01  2.00000E-01  1.44794E+00 ! Front view
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   2 EYE  -7.52864E-01  6.82277E-01  9.64262E-01 ! Front view, tilted
!        Q     9.09446E-01 -1.64981E-01 -3.78132E-01 -5.20183E-02
         VIEW  6.70618E-01 -3.39422E-01 -6.59594E-01
         RIGH  7.08620E-01  3.01537E-02  7.04946E-01
         UP    2.19385E-01  9.40151E-01 -2.60743E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   3 EYE  -6.58241E-01  6.85968E-01 -9.95751E-01 ! Back view, tilted
!        Q     3.36824E-01 -5.93912E-02 -9.25417E-01 -1.63176E-01
         VIEW  6.04023E-01 -3.42020E-01  7.19846E-01
         RIGH -7.66044E-01 -1.38778E-17  6.42788E-01
         UP    2.19846E-01  9.39693E-01  2.62003E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
SCEN GEOM NAVI FREE
     ISO  FELE FIEL ECRO 13 SCAL USER PROG 0.05 PAS 0.05 0.70 TERM
          SUPP LECT vmesh TERM
     TEXT ISCA
     COLO PAPE
     LIMA ON
SLER CAM1 3 NFRA 1
FREQ 1
TRAC OFFS FICH AVI NOCL NFTO 11 FPS 10 KFRE 4 COMP -1
     OBJE LECT vmesh TERM NFAI REND
GOTR LOOP 9 OFFS FICH AVI CONT NOCL
     OBJE LECT vmesh TERM NFAI REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT vmesh TERM NFAI REND
ENDPLAY
*========================================================================
FIN
```

plat03db.epx

```
Post treatment (visualization from alice file)
ECHO
 CONV WIN
RESU SPLI ALIC 'plat03.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 11
*========================================================================
PLAY
CAME   1 EYE   2.00000E-01  2.00000E-01  1.44794E+00 ! Front view
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   2 EYE  -7.52864E-01  6.82277E-01  9.64262E-01 ! Front view, tilted
!        Q     9.09446E-01 -1.64981E-01 -3.78132E-01 -5.20183E-02
         VIEW  6.70618E-01 -3.39422E-01 -6.59594E-01
         RIGH  7.08620E-01  3.01537E-02  7.04946E-01
         UP    2.19385E-01  9.40151E-01 -2.60743E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
CAME   3 EYE  -6.58241E-01  6.85968E-01 -9.95751E-01 ! Back view, tilted
!        Q     3.36824E-01 -5.93912E-02 -9.25417E-01 -1.63176E-01
         VIEW  6.04023E-01 -3.42020E-01  7.19846E-01
         RIGH -7.66044E-01 -1.38778E-17  6.42788E-01
         UP    2.19846E-01  9.39693E-01  2.62003E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  2.00000E-01  2.00000E-01  2.70606E-02
!RSPHERE:  2.84175E-01
!RADIUS :  1.42088E+00
!ASPECT :  1.00000E+00
!NEAR   :  1.10828E+00
!FAR    :  1.98923E+00
SCEN GEOM NAVI FREE
     ISO  FELE FIEL ECRO 13 SCAL USER PROG 0.05 PAS 0.05 0.70 TERM
          SUPP LECT vmesh TERM
     TEXT ISCA
     COLO PAPE
     LIMA ON
SLER CAM1 1 NFRA 1
TRAC OFFS FICH BMP
     OBJE LECT vmesh TERM NFAI REND
SLER CAM1 2 NFRA 1
TRAC OFFS FICH BMP
     OBJE LECT vmesh TERM NFAI REND
SLER CAM1 3 NFRA 1
TRAC OFFS FICH BMP
     OBJE LECT vmesh TERM NFAI REND
ENDPLAY
*========================================================================
FIN
```

q4gs11.epx

```
Q4GS11
ECHO
!CONV win
LAGR TRID
DIME ADAP NPOI 120 Q4GS 144 CL3D 144 ENDA TERM
GEOM LIBR POIN 121 Q4GS 100 CL3D 100 TERM
  0.0  0.0  0.0
  1.0  0.0  0.0
  2.0  0.0  0.0
  3.0  0.0  0.0
  4.0  0.0  0.0
  5.0  0.0  0.0
  6.0  0.0  0.0
  7.0  0.0  0.0
  8.0  0.0  0.0
  9.0  0.0  0.0
 10.0  0.0  0.0
  0.0  1.0  0.0
  1.0  1.0  0.0
  2.0  1.0  0.0
  3.0  1.0  0.0
  4.0  1.0  0.0
  5.0  1.0  0.0
  6.0  1.0  0.0
  7.0  1.0  0.0
  8.0  1.0  0.0
  9.0  1.0  0.0
 10.0  1.0  0.0
  0.0  2.0  0.0
  1.0  2.0  0.0
  2.0  2.0  0.0
  3.0  2.0  0.0
  4.0  2.0  0.0
  5.0  2.0  0.0
  6.0  2.0  0.0
  7.0  2.0  0.0
  8.0  2.0  0.0
  9.0  2.0  0.0
 10.0  2.0  0.0
  0.0  3.0  0.0
  1.0  3.0  0.0
  2.0  3.0  0.0
  3.0  3.0  0.0
  4.0  3.0  0.0
  5.0  3.0  0.0
  6.0  3.0  0.0
  7.0  3.0  0.0
  8.0  3.0  0.0
  9.0  3.0  0.0
 10.0  3.0  0.0
  0.0  4.0  0.0
  1.0  4.0  0.0
  2.0  4.0  0.0
  3.0  4.0  0.0
  4.0  4.0  0.0
  5.0  4.0  0.0
  6.0  4.0  0.0
  7.0  4.0  0.0
  8.0  4.0  0.0
  9.0  4.0  0.0
 10.0  4.0  0.0
  0.0  5.0  0.0
  1.0  5.0  0.0
  2.0  5.0  0.0
  3.0  5.0  0.0
  4.0  5.0  0.0
  5.0  5.0  0.0
  6.0  5.0  0.0
  7.0  5.0  0.0
  8.0  5.0  0.0
  9.0  5.0  0.0
 10.0  5.0  0.0
  0.0  6.0  0.0
  1.0  6.0  0.0
  2.0  6.0  0.0
  3.0  6.0  0.0
  4.0  6.0  0.0
  5.0  6.0  0.0
  6.0  6.0  0.0
  7.0  6.0  0.0
  8.0  6.0  0.0
  9.0  6.0  0.0
 10.0  6.0  0.0
  0.0  7.0  0.0
```

```
 1.0  7.0  0.0
 2.0  7.0  0.0
 3.0  7.0  0.0
 4.0  7.0  0.0
 5.0  7.0  0.0
 6.0  7.0  0.0
 7.0  7.0  0.0
 8.0  7.0  0.0
 9.0  7.0  0.0
10.0  7.0  0.0
 0.0  8.0  0.0
 1.0  8.0  0.0
 2.0  8.0  0.0
 3.0  8.0  0.0
 4.0  8.0  0.0
 5.0  8.0  0.0
 6.0  8.0  0.0
 7.0  8.0  0.0
 8.0  8.0  0.0
 9.0  8.0  0.0
10.0  8.0  0.0
 0.0  9.0  0.0
 1.0  9.0  0.0
 2.0  9.0  0.0
 3.0  9.0  0.0
 4.0  9.0  0.0
 5.0  9.0  0.0
 6.0  9.0  0.0
 7.0  9.0  0.0
 8.0  9.0  0.0
 9.0  9.0  0.0
10.0  9.0  0.0
 0.0 10.0  0.0
 1.0 10.0  0.0
 2.0 10.0  0.0
 3.0 10.0  0.0
 4.0 10.0  0.0
 5.0 10.0  0.0
 6.0 10.0  0.0
 7.0 10.0  0.0
 8.0 10.0  0.0
 9.0 10.0  0.0
10.0 10.0  0.0
    1    2   13   12
    2    3   14   13
    3    4   15   14
    4    5   16   15
    5    6   17   16
    6    7   18   17
    7    8   19   18
    8    9   20   19
    9   10   21   20
   10   11   22   21
   12   13   24   23
   13   14   25   24
   14   15   26   25
   15   16   27   26
   16   17   28   27
   17   18   29   28
   18   19   30   29
   19   20   31   30
   20   21   32   31
   21   22   33   32
   23   24   35   34
   24   25   36   35
   25   26   37   36
   26   27   38   37
   27   28   39   38
   28   29   40   39
   29   30   41   40
   30   31   42   41
   31   32   43   42
   32   33   44   43
   34   35   46   45
   35   36   47   46
   36   37   48   47
   37   38   49   48
   38   39   50   49
   39   40   51   50
   40   41   52   51
   41   42   53   52
   42   43   54   53
   43   44   55   54
   45   46   57   56
   46   47   58   57
   47   48   59   58
   48   49   60   59
   49   50   61   60
   50   51   62   61
   51   52   63   62
   52   53   64   63
   53   54   65   64
   54   55   66   65
   56   57   68   67
   57   58   69   68
   58   59   70   69
   59   60   71   70
   60   61   72   71
   61   62   73   72
   62   63   74   73
   63   64   75   74
   64   65   76   75
   65   66   77   76
   67   68   79   78
   68   69   80   79
   69   70   81   80
   70   71   82   81
   71   72   83   82
   72   73   84   83
   73   74   85   84
   74   75   86   85
   75   76   87   86
   76   77   88   87
   78   79   90   89
   79   80   91   90
   80   81   92   91
   81   82   93   92
   82   83   94   93
   83   84   95   94
   84   85   96   95
   85   86   97   96
   86   87   98   97
   87   88   99   98
   89   90  101  100
   90   91  102  101
   91   92  103  102
   92   93  104  103
   93   94  105  104
   94   95  106  105
   95   96  107  106
   96   97  108  107
   97   98  109  108
   98   99  110  109
  100  101  112  111
  101  102  113  112
  102  103  114  113
  103  104  115  114
  104  105  116  115
  105  106  117  116
  106  107  118  117
  107  108  119  118
  108  109  120  119
  109  110  121  120
    1    2   13   12
    2    3   14   13
    3    4   15   14
    4    5   16   15
    5    6   17   16
    6    7   18   17
    7    8   19   18
    8    9   20   19
    9   10   21   20
   10   11   22   21
   12   13   24   23
   13   14   25   24
   14   15   26   25
   15   16   27   26
   16   17   28   27
   17   18   29   28
   18   19   30   29
   19   20   31   30
   20   21   32   31
   21   22   33   32
   23   24   35   34
   24   25   36   35
   25   26   37   36
   26   27   38   37
   27   28   39   38
   28   29   40   39
   29   30   41   40
   30   31   42   41
   31   32   43   42
   32   33   44   43
   34   35   46   45
   35   36   47   46
   36   37   48   47
   37   38   49   48
   38   39   50   49
   39   40   51   50
   40   41   52   51
   41   42   53   52
   42   43   54   53
   43   44   55   54
   45   46   57   56
   46   47   58   57
   47   48   59   58
   48   49   60   59
   49   50   61   60
   50   51   62   61
   51   52   63   62
   52   53   64   63
   53   54   65   64
   54   55   66   65
   56   57   68   67
   57   58   69   68
   58   59   70   69
   59   60   71   70
   60   61   72   71
   61   62   73   72
   62   63   74   73
   63   64   75   74
   64   65   76   75
   65   66   77   76
   67   68   79   78
   68   69   80   79
   69   70   81   80
   70   71   82   81
   71   72   83   82
   72   73   84   83
   73   74   85   84
   74   75   86   85
   75   76   87   86
   76   77   88   87
   78   79   90   89
   79   80   91   90
   80   81   92   91
   81   82   93   92
   82   83   94   93
   83   84   95   94
   84   85   96   95
   85   86   97   96
   86   87   98   97
   87   88   99   98
   89   90  101  100
   90   91  102  101
   91   92  103  102
   92   93  104  103
   93   94  105  104
   94   95  106  105
   95   96  107  106
   96   97  108  107
   97   98  109  108
   98   99  110  109
  100  101  112  111
  101  102  113  112
  102  103  114  113
```

```
  103  104  115  114
  104  105  116  115
  105  106  117  116
  106  107  118  117
  107  108  119  118
  108  109  120  119
  109  110  121  120
COMP GROU 3 'plate' LECT 1 PAS 1 100 TERM
            'pres'  LECT 101 PAS 1 200 TERM
            'cplat' LECT plate TERM COND BOX X0 2.4 Y0 2.4 Z0 -1
                                             DX 5.2 DY 5.2 DZ  2
     EPAI 1.E-1 LECT plate _q4gs TERM
     NGRO 2 'cent' LECT plate TERM COND NEAR POIN 5 5 0
            'clamp' LECT 1 PAS 1 11 111 PAS 1 121
                         12 PAS 11 100
                         22 PAS 11 110 TERM
     COUL VERT LECT plate TERM
          JAUN LECT pres TERM
MATE LINE RO 8000. YOUN 2.E11 NU 0.0
          LECT plate _q4gs TERM
     IMPE PIMP RO 8000 PRES 10.E5 PREF 0
          TABP 2 0 1 100 1
          LECT pres _cl3d TERM
LINK COUP SPLT NONE
     BLOQ 123456 LECT clamp TERM
INIT ADAP SPLI LEVE 2 LECT cplat TERM
ECRI COOR DEPL VITE ACCE FINT FEXT CONT ECRO TFRE 1.E-3
     POIN LECT 1 TERM
     ELEM LECT 1 TERM
     FICH ALIC TEMP FREQ 1 POIN LECT cent TERM
OPTI NOTE STEP LIBR
 LNKS STAT
 log 1
CALC TINI 0. TEND 60.0E-3
*=================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
RESU ALIC TEMP GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dx_cent' DEPL COMP 1 NOEU LECT cent TERM
COUR 2 'dy_cent' DEPL COMP 2 NOEU LECT cent TERM
COUR 3 'dz_cent' DEPL COMP 3 NOEU LECT cent TERM
TRAC 1 2 3 AXES 1.0 'DISPL. [M]' YZER
LIST 1 2 3 AXES 1.0 'DISPL. [M]' YZER
*=================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
RESU ALIC TEMP GARD PSCR
SORT ARRE TEMP 2.4E-2 ! Max displacement occurs at this time
QUAL DEPL COMP 1 LECT cent TERM REFE  0.00000E+0 TOLE 1.E-3
     DEPL COMP 2 LECT cent TERM REFE  0.00000E+0 TOLE 1.E-3
     DEPL COMP 3 LECT cent TERM REFE  3.72745E-1 TOLE 1.E-2
*=================================================================
FIN
```

q4gs12.epx

```
Q4GS12
ECHO
!CONV win
LAGR TRID
DIME ADAP NPOI 120 Q4GS 144 CL3D 144 ENDA TERM
GEOM LIBR POIN 121 Q4GS 100 CL3D 100 TERM
  0.0  0.0  0.0
  1.0  0.0  0.0
  2.0  0.0  0.0
  3.0  0.0  0.0
  4.0  0.0  0.0
  5.0  0.0  0.0
  6.0  0.0  0.0
  7.0  0.0  0.0
  8.0  0.0  0.0
  9.0  0.0  0.0
 10.0  0.0  0.0
  0.0  1.0  0.0
  1.0  1.0  0.0
  2.0  1.0  0.0
  3.0  1.0  0.0
  4.0  1.0  0.0
  5.0  1.0  0.0
  6.0  1.0  0.0
  7.0  1.0  0.0
  8.0  1.0  0.0
  9.0  1.0  0.0
 10.0  1.0  0.0
  0.0  2.0  0.0
  1.0  2.0  0.0
  2.0  2.0  0.0
  3.0  2.0  0.0
  4.0  2.0  0.0
  5.0  2.0  0.0
  6.0  2.0  0.0
  7.0  2.0  0.0
  8.0  2.0  0.0
  9.0  2.0  0.0
 10.0  2.0  0.0
  0.0  3.0  0.0
  1.0  3.0  0.0
  2.0  3.0  0.0
  3.0  3.0  0.0
  4.0  3.0  0.0
  5.0  3.0  0.0
  6.0  3.0  0.0
  7.0  3.0  0.0
  8.0  3.0  0.0
  9.0  3.0  0.0
 10.0  3.0  0.0
  0.0  4.0  0.0
  1.0  4.0  0.0
  2.0  4.0  0.0
  3.0  4.0  0.0
  4.0  4.0  0.0
  5.0  4.0  0.0
  6.0  4.0  0.0
  7.0  4.0  0.0
  8.0  4.0  0.0
  9.0  4.0  0.0
 10.0  4.0  0.0
  0.0  5.0  0.0
  1.0  5.0  0.0
  2.0  5.0  0.0
  3.0  5.0  0.0
  4.0  5.0  0.0
  5.0  5.0  0.0
  6.0  5.0  0.0
  7.0  5.0  0.0
  8.0  5.0  0.0
  9.0  5.0  0.0
 10.0  5.0  0.0
  0.0  6.0  0.0
  1.0  6.0  0.0
  2.0  6.0  0.0
  3.0  6.0  0.0
  4.0  6.0  0.0
  5.0  6.0  0.0
  6.0  6.0  0.0
  7.0  6.0  0.0
  8.0  6.0  0.0
  9.0  6.0  0.0
 10.0  6.0  0.0
  0.0  7.0  0.0
  1.0  7.0  0.0
  2.0  7.0  0.0
  3.0  7.0  0.0
  4.0  7.0  0.0
  5.0  7.0  0.0
  6.0  7.0  0.0
  7.0  7.0  0.0
  8.0  7.0  0.0
  9.0  7.0  0.0
 10.0  7.0  0.0
  0.0  8.0  0.0
  1.0  8.0  0.0
  2.0  8.0  0.0
  3.0  8.0  0.0
  4.0  8.0  0.0
  5.0  8.0  0.0
  6.0  8.0  0.0
  7.0  8.0  0.0
  8.0  8.0  0.0
  9.0  8.0  0.0
 10.0  8.0  0.0
  0.0  9.0  0.0
  1.0  9.0  0.0
  2.0  9.0  0.0
  3.0  9.0  0.0
  4.0  9.0  0.0
  5.0  9.0  0.0
  6.0  9.0  0.0
  7.0  9.0  0.0
  8.0  9.0  0.0
  9.0  9.0  0.0
 10.0  9.0  0.0
  0.0 10.0  0.0
  1.0 10.0  0.0
  2.0 10.0  0.0
  3.0 10.0  0.0
  4.0 10.0  0.0
  5.0 10.0  0.0
  6.0 10.0  0.0
  7.0 10.0  0.0
  8.0 10.0  0.0
  9.0 10.0  0.0
 10.0 10.0  0.0
    1    2   13   12
    2    3   14   13
    3    4   15   14
    4    5   16   15
    5    6   17   16
    6    7   18   17
    7    8   19   18
    8    9   20   19
    9   10   21   20
   10   11   22   21
   12   13   24   23
   13   14   25   24
   14   15   26   25
   15   16   27   26
   16   17   28   27
   17   18   29   28
   18   19   30   29
   19   20   31   30
   20   21   32   31
   21   22   33   32
   23   24   35   34
   24   25   36   35
   25   26   37   36
   26   27   38   37
   27   28   39   38
   28   29   40   39
   29   30   41   40
   30   31   42   41
   31   32   43   42
   32   33   44   43
   34   35   46   45
   35   36   47   46
   36   37   48   47
   37   38   49   48
   38   39   50   49
   39   40   51   50
   40   41   52   51
   41   42   53   52
   42   43   54   53
   43   44   55   54
   45   46   57   56
   46   47   58   57
   47   48   59   58
   48   49   60   59
   49   50   61   60
   50   51   62   61
   51   52   63   62
```

```
  52   53   64   63
  53   54   65   64
  54   55   66   65
  56   57   68   67
  57   58   69   68
  58   59   70   69
  59   60   71   70
  60   61   72   71
  61   62   73   72
  62   63   74   73
  63   64   75   74
  64   65   76   75
  65   66   77   76
  67   68   79   78
  68   69   80   79
  69   70   81   80
  70   71   82   81
  71   72   83   82
  72   73   84   83
  73   74   85   84
  74   75   86   85
  75   76   87   86
  76   77   88   87
  78   79   90   89
  79   80   91   90
  80   81   92   91
  81   82   93   92
  82   83   94   93
  83   84   95   94
  84   85   96   95
  85   86   97   96
  86   87   98   97
  87   88   99   98
  89   90  101  100
  90   91  102  101
  91   92  103  102
  92   93  104  103
  93   94  105  104
  94   95  106  105
  95   96  107  106
  96   97  108  107
  97   98  109  108
  98   99  110  109
 100  101  112  111
 101  102  113  112
 102  103  114  113
 103  104  115  114
 104  105  116  115
 105  106  117  116
 106  107  118  117
 107  108  119  118
 108  109  120  119
 109  110  121  120
   1    2   13   12
   2    3   14   13
   3    4   15   14
   4    5   16   15
   5    6   17   16
   6    7   18   17
   7    8   19   18
   8    9   20   19
   9   10   21   20
  10   11   22   21
  12   13   24   23
  13   14   25   24
  14   15   26   25
  15   16   27   26
  16   17   28   27
  17   18   29   28
  18   19   30   29
  19   20   31   30
  20   21   32   31
  21   22   33   32
  23   24   35   34
  24   25   36   35
  25   26   37   36
  26   27   38   37
  27   28   39   38
  28   29   40   39
  29   30   41   40
  30   31   42   41
  31   32   43   42
  32   33   44   43
  34   35   46   45
  35   36   47   46
  36   37   48   47
  37   38   49   48
  38   39   50   49
  39   40   51   50
  40   41   52   51
  41   42   53   52
  42   43   54   53
  43   44   55   54
  45   46   57   56
  46   47   58   57
  47   48   59   58
  48   49   60   59
  49   50   61   60
  50   51   62   61
  51   52   63   62
  52   53   64   63
  53   54   65   64
  54   55   66   65
  56   57   68   67
  57   58   69   68
  58   59   70   69
  59   60   71   70
  60   61   72   71
  61   62   73   72
  62   63   74   73
  63   64   75   74
  64   65   76   75
  65   66   77   76
  67   68   79   78
  68   69   80   79
  69   70   81   80
  70   71   82   81
  71   72   83   82
  72   73   84   83
  73   74   85   84
  74   75   86   85
  75   76   87   86
  76   77   88   87
  78   79   90   89
  79   80   91   90
  80   81   92   91
  81   82   93   92
  82   83   94   93
  83   84   95   94
  84   85   96   95
  85   86   97   96
  86   87   98   97
  87   88   99   98
  89   90  101  100
  90   91  102  101
  91   92  103  102
  92   93  104  103
  93   94  105  104
  94   95  106  105
  95   96  107  106
  96   97  108  107
  97   98  109  108
  98   99  110  109
 100  101  112  111
 101  102  113  112
 102  103  114  113
 103  104  115  114
 104  105  116  115
 105  106  117  116
 106  107  118  117
 107  108  119  118
 108  109  120  119
 109  110  121  120
COMP GROU 3 'plate' LECT 1 PAS 1 100 TERM
            'pres'  LECT 101 PAS 1 200 TERM
            'cplat' LECT plate TERM COND BOX X0 2.4 Y0 2.4 Z0 -1
                                         DX 5.2 DY 5.2 DZ  2
     EPAI 1.E-1 LECT plate _q4gs TERM
     NGRO 2 'cent' LECT plate TERM COND NEAR POIN 5 5 0
            'clamp' LECT 1 PAS 1 11 111 PAS 1 121
                         12 PAS 11 100
                         22 PAS 11 110 TERM
     COUL VERT LECT plate TERM
          JAUN LECT pres TERM
MATE LINE RO 8000. YOUN 2.E11 NU 0.0
          LECT plate _q4gs TERM
     IMPE PIMP RO 8000 PRES 10.E5 PREF 0
          TABP 2 0 1 100 1
          LECT pres _cl3d TERM
LINK COUP SPLT NONE
     BLOQ 123456 LECT clamp TERM
INIT ADAP SPLI LEVE 2 LECT cplat TERM
ECRI COOR DEPL VITE ACCE FINT FEXT CONT ECRO TFRE 1.E-3
     POIN LECT 1 TERM
     ELEM LECT 1 TERM
     FICH ALIC TEMP FREQ 1 POIN LECT cent TERM
OPTI NOTE STEP LIBR
 LNKS STAT
 log 1
 ADAP DHAN VITE
CALC TINI 0. TEND 60.0E-3
*=================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
RESU ALIC TEMP GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dx_cent' DEPL COMP 1 NOEU LECT cent TERM
COUR 2 'dy_cent' DEPL COMP 2 NOEU LECT cent TERM
COUR 3 'dz_cent' DEPL COMP 3 NOEU LECT cent TERM
TRAC 1 2 3 AXES 1.0 'DISPL. [M]' YZER
LIST 1 2 3 AXES 1.0 'DISPL. [M]' YZER
RCOU 11 'dx_cent' FICH 'q4gs11.pun' RENA 'dx_cent_11'
RCOU 12 'dy_cent' FICH 'q4gs11.pun' RENA 'dy_cent_11'
RCOU 13 'dz_cent' FICH 'q4gs11.pun' RENA 'dz_cent_11'
TRAC 3 13 AXES 1.0 'DISPL. [M]' YZER
COLO NOIR ROUG
*=================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
RESU ALIC TEMP GARD PSCR
SORT ARRE TEMP 2.4E-2 ! Max displacement occurs at this time
QUAL DEPL COMP 1 LECT cent TERM REFE  0.00000E+0 TOLE 1.E-3
     DEPL COMP 2 LECT cent TERM REFE  0.00000E+0 TOLE 1.E-3
     DEPL COMP 3 LECT cent TERM REFE  3.72745E-1 TOLE 1.E-2
*=================================================================
FIN
```

q4gs13.epx

```
Q4GS13
ECHO
!CONV win
LAGR TRID
DIME ADAP NPOI 120 Q4GS 144 CL3D 144 ENDA TERM
GEOM LIBR POIN 121 Q4GS 100 CL3D 100 TERM
  0.0  0.0  0.0
  1.0  0.0  0.0
  2.0  0.0  0.0
  3.0  0.0  0.0
  4.0  0.0  0.0
  5.0  0.0  0.0
  6.0  0.0  0.0
  7.0  0.0  0.0
  8.0  0.0  0.0
  9.0  0.0  0.0
 10.0  0.0  0.0
  0.0  1.0  0.0
  1.0  1.0  0.0
  2.0  1.0  0.0
  3.0  1.0  0.0
  4.0  1.0  0.0
```

```
 5.0  1.0  0.0
 6.0  1.0  0.0
 7.0  1.0  0.0
 8.0  1.0  0.0
 9.0  1.0  0.0
10.0  1.0  0.0
 0.0  2.0  0.0
 1.0  2.0  0.0
 2.0  2.0  0.0
 3.0  2.0  0.0
 4.0  2.0  0.0
 5.0  2.0  0.0
 6.0  2.0  0.0
 7.0  2.0  0.0
 8.0  2.0  0.0
 9.0  2.0  0.0
10.0  2.0  0.0
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 4.0  3.0  0.0
 5.0  3.0  0.0
 6.0  3.0  0.0
 7.0  3.0  0.0
 8.0  3.0  0.0
 9.0  3.0  0.0
10.0  3.0  0.0
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 3.0  4.0  0.0
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 6.0  4.0  0.0
 7.0  4.0  0.0
 8.0  4.0  0.0
 9.0  4.0  0.0
10.0  4.0  0.0
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 2.0  5.0  0.0
 3.0  5.0  0.0
 4.0  5.0  0.0
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 6.0  5.0  0.0
 7.0  5.0  0.0
 8.0  5.0  0.0
 9.0  5.0  0.0
10.0  5.0  0.0
 0.0  6.0  0.0
 1.0  6.0  0.0
 2.0  6.0  0.0
 3.0  6.0  0.0
 4.0  6.0  0.0
 5.0  6.0  0.0
 6.0  6.0  0.0
 7.0  6.0  0.0
 8.0  6.0  0.0
 9.0  6.0  0.0
10.0  6.0  0.0
 0.0  7.0  0.0
 1.0  7.0  0.0
 2.0  7.0  0.0
 3.0  7.0  0.0
 4.0  7.0  0.0
 5.0  7.0  0.0
 6.0  7.0  0.0
 7.0  7.0  0.0
 8.0  7.0  0.0
 9.0  7.0  0.0
10.0  7.0  0.0
 0.0  8.0  0.0
 1.0  8.0  0.0
 2.0  8.0  0.0
 3.0  8.0  0.0
 4.0  8.0  0.0
 5.0  8.0  0.0
 6.0  8.0  0.0
 7.0  8.0  0.0
 8.0  8.0  0.0
 9.0  8.0  0.0
10.0  8.0  0.0
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 1.0  9.0  0.0
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 3.0  9.0  0.0
 4.0  9.0  0.0
 5.0  9.0  0.0
 6.0  9.0  0.0
 7.0  9.0  0.0
 8.0  9.0  0.0
 9.0  9.0  0.0
10.0  9.0  0.0
 0.0 10.0  0.0
 1.0 10.0  0.0
 2.0 10.0  0.0
 3.0 10.0  0.0
 4.0 10.0  0.0
 5.0 10.0  0.0
 6.0 10.0  0.0
 7.0 10.0  0.0
 8.0 10.0  0.0
 9.0 10.0  0.0
10.0 10.0  0.0
   1    2   13   12
   2    3   14   13
   3    4   15   14
   4    5   16   15
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   6    7   18   17
   7    8   19   18
   8    9   20   19
   9   10   21   20
  10   11   22   21
  12   13   24   23
  13   14   25   24
  14   15   26   25
  15   16   27   26
  16   17   28   27
  17   18   29   28
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  19   20   31   30
  20   21   32   31
  21   22   33   32
  23   24   35   34
  24   25   36   35
  25   26   37   36
  26   27   38   37
  27   28   39   38
  28   29   40   39
  29   30   41   40
  30   31   42   41
  31   32   43   42
  32   33   44   43
  34   35   46   45
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  37   38   49   48
  38   39   50   49
  39   40   51   50
  40   41   52   51
  41   42   53   52
  42   43   54   53
  43   44   55   54
  45   46   57   56
  46   47   58   57
  47   48   59   58
  48   49   60   59
  49   50   61   60
  50   51   62   61
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  52   53   64   63
  53   54   65   64
  54   55   66   65
  56   57   68   67
  57   58   69   68
  58   59   70   69
  59   60   71   70
  60   61   72   71
  61   62   73   72
  62   63   74   73
  63   64   75   74
  64   65   76   75
  65   66   77   76
  67   68   79   78
  68   69   80   79
  69   70   81   80
  70   71   82   81
  71   72   83   82
  72   73   84   83
  73   74   85   84
  74   75   86   85
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  76   77   88   87
  78   79   90   89
  79   80   91   90
  80   81   92   91
  81   82   93   92
  82   83   94   93
  83   84   95   94
  84   85   96   95
  85   86   97   96
  86   87   98   97
  87   88   99   98
  89   90  101  100
  90   91  102  101
  91   92  103  102
  92   93  104  103
  93   94  105  104
  94   95  106  105
  95   96  107  106
  96   97  108  107
  97   98  109  108
  98   99  110  109
 100  101  112  111
 101  102  113  112
 102  103  114  113
 103  104  115  114
 104  105  116  115
 105  106  117  116
 106  107  118  117
 107  108  119  118
 108  109  120  119
 109  110  121  120
   1    2   13   12
   2    3   14   13
   3    4   15   14
   4    5   16   15
   5    6   17   16
   6    7   18   17
   7    8   19   18
   8    9   20   19
   9   10   21   20
  10   11   22   21
  12   13   24   23
  13   14   25   24
  14   15   26   25
  15   16   27   26
  16   17   28   27
  17   18   29   28
  18   19   30   29
  19   20   31   30
  20   21   32   31
  21   22   33   32
  23   24   35   34
  24   25   36   35
  25   26   37   36
  26   27   38   37
  27   28   39   38
  28   29   40   39
  29   30   41   40
  30   31   42   41
  31   32   43   42
  32   33   44   43
  34   35   46   45
```

```
   35   36   47   46
   36   37   48   47
   37   38   49   48
   38   39   50   49
   39   40   51   50
   40   41   52   51
   41   42   53   52
   42   43   54   53
   43   44   55   54
   45   46   57   56
   46   47   58   57
   47   48   59   58
   48   49   60   59
   49   50   61   60
   50   51   62   61
   51   52   63   62
   52   53   64   63
   53   54   65   64
   54   55   66   65
   56   57   68   67
   57   58   69   68
   58   59   70   69
   59   60   71   70
   60   61   72   71
   61   62   73   72
   62   63   74   73
   63   64   75   74
   64   65   76   75
   65   66   77   76
   67   68   79   78
   68   69   80   79
   69   70   81   80
   70   71   82   81
   71   72   83   82
   72   73   84   83
   73   74   85   84
   74   75   86   85
   75   76   87   86
   76   77   88   87
   78   79   90   89
   79   80   91   90
   80   81   92   91
   81   82   93   92
   82   83   94   93
   83   84   95   94
   84   85   96   95
   85   86   97   96
   86   87   98   97
   87   88   99   98
   89   90  101  100
   90   91  102  101
   91   92  103  102
   92   93  104  103
   93   94  105  104
   94   95  106  105
   95   96  107  106
   96   97  108  107
   97   98  109  108
   98   99  110  109
  100  101  112  111
  101  102  113  112
  102  103  114  113
  103  104  115  114
  104  105  116  115
  105  106  117  116
  106  107  118  117
  107  108  119  118
  108  109  120  119
  109  110  121  120
COMP GROU 3 'plate' LECT 1 PAS 1 100 TERM
            'pres'  LECT 101 PAS 1 200 TERM
            'cplat' LECT plate TERM COND BOX X0 2.4 Y0 2.4 Z0 -1
                                         DX 5.2 DY 5.2 DZ  2
     EPAI 1.E-1 LECT plate _q4gs TERM
     NGRO 2 'cent' LECT plate TERM COND NEAR POIN 5 5 0
            'clamp' LECT 1 PAS 1 11 111 PAS 1 121
                         12 PAS 11 100
                         22 PAS 11 110 TERM
     COUL VERT LECT plate TERM
          JAUN LECT pres TERM
MATE LINE RO 8000. YOUN 2.E11 NU 0.0
          LECT plate _q4gs TERM
     IMPE PIMP RO 8000 PRES 10.E5 PREF 0
          TABP 2 0 1 100 1
          LECT pres _cl3d TERM
LINK COUP SPLT NONE
     BLOQ 123456 LECT clamp TERM
INIT ADAP SPLI LEVE 2 LECT cplat TERM
ECRI COOR DEPL VITE ACCE FINT FEXT CONT ECRO TFRE 1.E-3
     POIN LECT 1 TERM
     ELEM LECT 1 TERM
     FICH ALIC TEMP FREQ 1 POIN LECT cent TERM
OPTI NOTE STEP LIBR
 LNKS STAT
 log 1
 ADAP DHAN
CALC TINI 0. TEND 60.0E-3
*=================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
RESU ALIC TEMP GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dx_cent' DEPL COMP 1 NOEU LECT cent TERM
COUR 2 'dy_cent' DEPL COMP 2 NOEU LECT cent TERM
COUR 3 'dz_cent' DEPL COMP 3 NOEU LECT cent TERM
TRAC 1 2 3 AXES 1.0 'DISPL. [M]' YZER
LIST 1 2 3 AXES 1.0 'DISPL. [M]' YZER
RCOU 11 'dx_cent' FICH 'q4gs11.pun' RENA 'dx_cent_11'
RCOU 12 'dy_cent' FICH 'q4gs11.pun' RENA 'dy_cent_11'
RCOU 13 'dz_cent' FICH 'q4gs11.pun' RENA 'dz_cent_11'
TRAC 3 13 AXES 1.0 'DISPL. [M]' YZER
COLO NOIR ROUG
*=================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
RESU ALIC TEMP GARD PSCR
SORT ARRE TEMP 2.4E-2 ! Max displacement occurs at this time
QUAL DEPL COMP 1 LECT cent TERM REFE  0.00000E+0 TOLE 1.E-3
     DEPL COMP 2 LECT cent TERM REFE  0.00000E+0 TOLE 1.E-3
     DEPL COMP 3 LECT cent TERM REFE  3.72745E-1 TOLE 1.E-2
*=================================================================
FIN
```

q4gs14.epx

```
Q4GS14
ECHO
!CONV win
LAGR TRID
DIME ADAP NPOI 652 Q4GS 816 CL3D 816 ENDA TERM
GEOM LIBR POIN 121 Q4GS 100 CL3D 100 TERM
  0.0  0.0  0.0
  1.0  0.0  0.0
  2.0  0.0  0.0
  3.0  0.0  0.0
  4.0  0.0  0.0
  5.0  0.0  0.0
  6.0  0.0  0.0
  7.0  0.0  0.0
  8.0  0.0  0.0
  9.0  0.0  0.0
 10.0  0.0  0.0
  0.0  1.0  0.0
  1.0  1.0  0.0
  2.0  1.0  0.0
  3.0  1.0  0.0
  4.0  1.0  0.0
  5.0  1.0  0.0
  6.0  1.0  0.0
  7.0  1.0  0.0
  8.0  1.0  0.0
  9.0  1.0  0.0
 10.0  1.0  0.0
  0.0  2.0  0.0
  1.0  2.0  0.0
  2.0  2.0  0.0
  3.0  2.0  0.0
  4.0  2.0  0.0
  5.0  2.0  0.0
  6.0  2.0  0.0
  7.0  2.0  0.0
  8.0  2.0  0.0
  9.0  2.0  0.0
 10.0  2.0  0.0
  0.0  3.0  0.0
  1.0  3.0  0.0
  2.0  3.0  0.0
  3.0  3.0  0.0
  4.0  3.0  0.0
  5.0  3.0  0.0
  6.0  3.0  0.0
  7.0  3.0  0.0
  8.0  3.0  0.0
  9.0  3.0  0.0
 10.0  3.0  0.0
  0.0  4.0  0.0
  1.0  4.0  0.0
  2.0  4.0  0.0
  3.0  4.0  0.0
  4.0  4.0  0.0
  5.0  4.0  0.0
  6.0  4.0  0.0
  7.0  4.0  0.0
  8.0  4.0  0.0
  9.0  4.0  0.0
 10.0  4.0  0.0
  0.0  5.0  0.0
  1.0  5.0  0.0
  2.0  5.0  0.0
  3.0  5.0  0.0
  4.0  5.0  0.0
  5.0  5.0  0.0
  6.0  5.0  0.0
  7.0  5.0  0.0
  8.0  5.0  0.0
  9.0  5.0  0.0
 10.0  5.0  0.0
  0.0  6.0  0.0
  1.0  6.0  0.0
  2.0  6.0  0.0
  3.0  6.0  0.0
  4.0  6.0  0.0
  5.0  6.0  0.0
  6.0  6.0  0.0
  7.0  6.0  0.0
  8.0  6.0  0.0
  9.0  6.0  0.0
 10.0  6.0  0.0
  0.0  7.0  0.0
  1.0  7.0  0.0
  2.0  7.0  0.0
  3.0  7.0  0.0
  4.0  7.0  0.0
  5.0  7.0  0.0
  6.0  7.0  0.0
  7.0  7.0  0.0
  8.0  7.0  0.0
  9.0  7.0  0.0
 10.0  7.0  0.0
  0.0  8.0  0.0
  1.0  8.0  0.0
  2.0  8.0  0.0
  3.0  8.0  0.0
  4.0  8.0  0.0
  5.0  8.0  0.0
  6.0  8.0  0.0
  7.0  8.0  0.0
  8.0  8.0  0.0
  9.0  8.0  0.0
 10.0  8.0  0.0
  0.0  9.0  0.0
```

```
  1.0  9.0  0.0
  2.0  9.0  0.0
  3.0  9.0  0.0
  4.0  9.0  0.0
  5.0  9.0  0.0
  6.0  9.0  0.0
  7.0  9.0  0.0
  8.0  9.0  0.0
  9.0  9.0  0.0
 10.0  9.0  0.0
  0.0 10.0  0.0
  1.0 10.0  0.0
  2.0 10.0  0.0
  3.0 10.0  0.0
  4.0 10.0  0.0
  5.0 10.0  0.0
  6.0 10.0  0.0
  7.0 10.0  0.0
  8.0 10.0  0.0
  9.0 10.0  0.0
 10.0 10.0  0.0
    1    2   13   12
    2    3   14   13
    3    4   15   14
    4    5   16   15
    5    6   17   16
    6    7   18   17
    7    8   19   18
    8    9   20   19
    9   10   21   20
   10   11   22   21
   12   13   24   23
   13   14   25   24
   14   15   26   25
   15   16   27   26
   16   17   28   27
   17   18   29   28
   18   19   30   29
   19   20   31   30
   20   21   32   31
   21   22   33   32
   23   24   35   34
   24   25   36   35
   25   26   37   36
   26   27   38   37
   27   28   39   38
   28   29   40   39
   29   30   41   40
   30   31   42   41
   31   32   43   42
   32   33   44   43
   34   35   46   45
   35   36   47   46
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   37   38   49   48
   38   39   50   49
   39   40   51   50
   40   41   52   51
   41   42   53   52
   42   43   54   53
   43   44   55   54
   45   46   57   56
   46   47   58   57
   47   48   59   58
   48   49   60   59
   49   50   61   60
   50   51   62   61
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   52   53   64   63
   53   54   65   64
   54   55   66   65
   56   57   68   67
   57   58   69   68
   58   59   70   69
   59   60   71   70
   60   61   72   71
   61   62   73   72
   62   63   74   73
   63   64   75   74
   64   65   76   75
   65   66   77   76
   67   68   79   78
   68   69   80   79
   69   70   81   80
   70   71   82   81
   71   72   83   82
   72   73   84   83
   73   74   85   84
   74   75   86   85
   75   76   87   86
   76   77   88   87
   78   79   90   89
   79   80   91   90
   80   81   92   91
   81   82   93   92
   82   83   94   93
   83   84   95   94
   84   85   96   95
   85   86   97   96
   86   87   98   97
   87   88   99   98
   89   90  101  100
   90   91  102  101
   91   92  103  102
   92   93  104  103
   93   94  105  104
   94   95  106  105
   95   96  107  106
   96   97  108  107
   97   98  109  108
   98   99  110  109
  100  101  112  111
  101  102  113  112
  102  103  114  113
  103  104  115  114
  104  105  116  115
  105  106  117  116
  106  107  118  117
```

```
  107  108  119  118
  108  109  120  119
  109  110  121  120
    1    2   13   12
    2    3   14   13
    3    4   15   14
    4    5   16   15
    5    6   17   16
    6    7   18   17
    7    8   19   18
    8    9   20   19
    9   10   21   20
   10   11   22   21
   12   13   24   23
   13   14   25   24
   14   15   26   25
   15   16   27   26
   16   17   28   27
   17   18   29   28
   18   19   30   29
   19   20   31   30
   20   21   32   31
   21   22   33   32
   23   24   35   34
   24   25   36   35
   25   26   37   36
   26   27   38   37
   27   28   39   38
   28   29   40   39
   29   30   41   40
   30   31   42   41
   31   32   43   42
   32   33   44   43
   34   35   46   45
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   37   38   49   48
   38   39   50   49
   39   40   51   50
   40   41   52   51
   41   42   53   52
   42   43   54   53
   43   44   55   54
   45   46   57   56
   46   47   58   57
   47   48   59   58
   48   49   60   59
   49   50   61   60
   50   51   62   61
   51   52   63   62
   52   53   64   63
   53   54   65   64
   54   55   66   65
   56   57   68   67
   57   58   69   68
   58   59   70   69
   59   60   71   70
   60   61   72   71
   61   62   73   72
   62   63   74   73
   63   64   75   74
   64   65   76   75
   65   66   77   76
   67   68   79   78
   68   69   80   79
   69   70   81   80
   70   71   82   81
   71   72   83   82
   72   73   84   83
   73   74   85   84
   74   75   86   85
   75   76   87   86
   76   77   88   87
   78   79   90   89
   79   80   91   90
   80   81   92   91
   81   82   93   92
   82   83   94   93
   83   84   95   94
   84   85   96   95
   85   86   97   96
   86   87   98   97
   87   88   99   98
   89   90  101  100
   90   91  102  101
   91   92  103  102
   92   93  104  103
   93   94  105  104
   94   95  106  105
   95   96  107  106
   96   97  108  107
   97   98  109  108
   98   99  110  109
  100  101  112  111
  101  102  113  112
  102  103  114  113
  103  104  115  114
  104  105  116  115
  105  106  117  116
  106  107  118  117
  107  108  119  118
  108  109  120  119
  109  110  121  120
COMP GROU 3 'plate' LECT 1 PAS 1 100 TERM
            'pres'  LECT 101 PAS 1 200 TERM
            'cplat' LECT plate TERM COND BOX X0 2.4 Y0 2.4 Z0 -1
                                           DX 5.2 DY 5.2 DZ  2
     EPAI 1.E-1 LECT plate _q4gs TERM
     NGRO 2 'cent' LECT plate TERM COND NEAR POIN 5 5 0
            'clamp' LECT 1 PAS 1 11 111 PAS 1 121
                        12 PAS 11 100
                        22 PAS 11 110 TERM
     COUL VERT LECT plate TERM
          JAUN LECT pres TERM
MATE LINE RO 8000. YOUN 2.E11 NU 0.0
          LECT plate _q4gs TERM
     IMPE PIMP RO 8000 PRES 10.E5 PREF 0
          TABP 2 0 1 100 1
```

```
          LECT pres _cl3d TERM
LINK COUP SPLT NONE
     BLOQ 123456 LECT clamp TERM
INIT ADAP SPLI LEVE 3 LECT cplat TERM
ECRI COOR DEPL VITE ACCE FINT FEXT CONT ECRO TFRE 1.E-3
     POIN LECT 1 TERM
     ELEM LECT 1 TERM
     FICH ALIC TEMP FREQ 1 POIN LECT cent TERM
OPTI NOTE STEP LIBR
 LNKS STAT
 log 1
 ADAP RCON
CALC TINI 0. TEND 60.0E-3
*==================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
RESU ALIC TEMP GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dx_cent' DEPL COMP 1 NOEU LECT cent TERM
COUR 2 'dy_cent' DEPL COMP 2 NOEU LECT cent TERM
COUR 3 'dz_cent' DEPL COMP 3 NOEU LECT cent TERM
TRAC 1 2 3 AXES 1.0 'DISPL. [M]' YZER
LIST 1 2 3 AXES 1.0 'DISPL. [M]' YZER
*==================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
RESU ALIC TEMP GARD PSCR
SORT ARRE TEMP 2.4E-2 ! Max displacement occurs at this time
QUAL DEPL COMP 1 LECT cent TERM REFE  0.00000E+0 TOLE 1.E-3
     DEPL COMP 2 LECT cent TERM REFE  0.00000E+0 TOLE 1.E-3
     DEPL COMP 3 LECT cent TERM REFE  3.74479E-1 TOLE 1.E-2
*==================================================================
FIN
```

q4gs16.epx

```
Q4GS16
ECHO
!CONV win
LAGR TRID
DIME ADAP NPOI 652 Q4GS 816 CL3D 816 ENDA TERM
GEOM LIBR POIN 121 Q4GS 100 CL3D 100 TERM
  0.0  0.0  0.0
  1.0  0.0  0.0
  2.0  0.0  0.0
  3.0  0.0  0.0
  4.0  0.0  0.0
  5.0  0.0  0.0
  6.0  0.0  0.0
  7.0  0.0  0.0
  8.0  0.0  0.0
  9.0  0.0  0.0
 10.0  0.0  0.0
  0.0  1.0  0.0
  1.0  1.0  0.0
  2.0  1.0  0.0
  3.0  1.0  0.0
  4.0  1.0  0.0
  5.0  1.0  0.0
  6.0  1.0  0.0
  7.0  1.0  0.0
  8.0  1.0  0.0
  9.0  1.0  0.0
 10.0  1.0  0.0
  0.0  2.0  0.0
  1.0  2.0  0.0
  2.0  2.0  0.0
  3.0  2.0  0.0
  4.0  2.0  0.0
  5.0  2.0  0.0
  6.0  2.0  0.0
  7.0  2.0  0.0
  8.0  2.0  0.0
  9.0  2.0  0.0
 10.0  2.0  0.0
  0.0  3.0  0.0
  1.0  3.0  0.0
  2.0  3.0  0.0
  3.0  3.0  0.0
  4.0  3.0  0.0
  5.0  3.0  0.0
  6.0  3.0  0.0
  7.0  3.0  0.0
  8.0  3.0  0.0
  9.0  3.0  0.0
 10.0  3.0  0.0
  0.0  4.0  0.0
  1.0  4.0  0.0
  2.0  4.0  0.0
  3.0  4.0  0.0
  4.0  4.0  0.0
  5.0  4.0  0.0
  6.0  4.0  0.0
  7.0  4.0  0.0
  8.0  4.0  0.0
  9.0  4.0  0.0
 10.0  4.0  0.0
  0.0  5.0  0.0
  1.0  5.0  0.0
  2.0  5.0  0.0
  3.0  5.0  0.0
  4.0  5.0  0.0
  5.0  5.0  0.0
  6.0  5.0  0.0
  7.0  5.0  0.0
  8.0  5.0  0.0
  9.0  5.0  0.0
 10.0  5.0  0.0
  0.0  6.0  0.0
  1.0  6.0  0.0
  2.0  6.0  0.0
  3.0  6.0  0.0
  4.0  6.0  0.0
  5.0  6.0  0.0
  6.0  6.0  0.0
  7.0  6.0  0.0
  8.0  6.0  0.0
  9.0  6.0  0.0
 10.0  6.0  0.0
  0.0  7.0  0.0
  1.0  7.0  0.0
  2.0  7.0  0.0
  3.0  7.0  0.0
  4.0  7.0  0.0
  5.0  7.0  0.0
  6.0  7.0  0.0
  7.0  7.0  0.0
  8.0  7.0  0.0
  9.0  7.0  0.0
 10.0  7.0  0.0
  0.0  8.0  0.0
  1.0  8.0  0.0
  2.0  8.0  0.0
  3.0  8.0  0.0
  4.0  8.0  0.0
  5.0  8.0  0.0
  6.0  8.0  0.0
  7.0  8.0  0.0
  8.0  8.0  0.0
  9.0  8.0  0.0
 10.0  8.0  0.0
  0.0  9.0  0.0
  1.0  9.0  0.0
  2.0  9.0  0.0
  3.0  9.0  0.0
  4.0  9.0  0.0
  5.0  9.0  0.0
  6.0  9.0  0.0
  7.0  9.0  0.0
  8.0  9.0  0.0
  9.0  9.0  0.0
 10.0  9.0  0.0
  0.0 10.0  0.0
  1.0 10.0  0.0
  2.0 10.0  0.0
  3.0 10.0  0.0
  4.0 10.0  0.0
  5.0 10.0  0.0
  6.0 10.0  0.0
  7.0 10.0  0.0
  8.0 10.0  0.0
  9.0 10.0  0.0
 10.0 10.0  0.0
    1    2   13   12
    2    3   14   13
    3    4   15   14
    4    5   16   15
    5    6   17   16
    6    7   18   17
    7    8   19   18
    8    9   20   19
    9   10   21   20
   10   11   22   21
   12   13   24   23
   13   14   25   24
   14   15   26   25
   15   16   27   26
   16   17   28   27
   17   18   29   28
   18   19   30   29
   19   20   31   30
   20   21   32   31
   21   22   33   32
   23   24   35   34
   24   25   36   35
   25   26   37   36
   26   27   38   37
   27   28   39   38
   28   29   40   39
   29   30   41   40
   30   31   42   41
   31   32   43   42
   32   33   44   43
   34   35   46   45
   35   36   47   46
   36   37   48   47
   37   38   49   48
   38   39   50   49
   39   40   51   50
   40   41   52   51
   41   42   53   52
   42   43   54   53
   43   44   55   54
   45   46   57   56
   46   47   58   57
   47   48   59   58
   48   49   60   59
   49   50   61   60
   50   51   62   61
   51   52   63   62
   52   53   64   63
   53   54   65   64
   54   55   66   65
   56   57   68   67
   57   58   69   68
   58   59   70   69
   59   60   71   70
   60   61   72   71
   61   62   73   72
   62   63   74   73
   63   64   75   74
   64   65   76   75
   65   66   77   76
   67   68   79   78
   68   69   80   79
   69   70   81   80
   70   71   82   81
   71   72   83   82
   72   73   84   83
   73   74   85   84
   74   75   86   85
```

```
  75   76   87   86
  76   77   88   87
  78   79   90   89
  79   80   91   90
  80   81   92   91
  81   82   93   92
  82   83   94   93
  83   84   95   94
  84   85   96   95
  85   86   97   96
  86   87   98   97
  87   88   99   98
  89   90  101  100
  90   91  102  101
  91   92  103  102
  92   93  104  103
  93   94  105  104
  94   95  106  105
  95   96  107  106
  96   97  108  107
  97   98  109  108
  98   99  110  109
 100  101  112  111
 101  102  113  112
 102  103  114  113
 103  104  115  114
 104  105  116  115
 105  106  117  116
 106  107  118  117
 107  108  119  118
 108  109  120  119
 109  110  121  120
   1    2   13   12
   2    3   14   13
   3    4   15   14
   4    5   16   15
   5    6   17   16
   6    7   18   17
   7    8   19   18
   8    9   20   19
   9   10   21   20
  10   11   22   21
  12   13   24   23
  13   14   25   24
  14   15   26   25
  15   16   27   26
  16   17   28   27
  17   18   29   28
  18   19   30   29
  19   20   31   30
  20   21   32   31
  21   22   33   32
  23   24   35   34
  24   25   36   35
  25   26   37   36
  26   27   38   37
  27   28   39   38
  28   29   40   39
  29   30   41   40
  30   31   42   41
  31   32   43   42
  32   33   44   43
  34   35   46   45
  35   36   47   46
  36   37   48   47
  37   38   49   48
  38   39   50   49
  39   40   51   50
  40   41   52   51
  41   42   53   52
  42   43   54   53
  43   44   55   54
  45   46   57   56
  46   47   58   57
  47   48   59   58
  48   49   60   59
  49   50   61   60
  50   51   62   61
  51   52   63   62
  52   53   64   63
  53   54   65   64
  54   55   66   65
  56   57   68   67
  57   58   69   68
  58   59   70   69
  59   60   71   70
  60   61   72   71
  61   62   73   72
  62   63   74   73
  63   64   75   74
  64   65   76   75
  65   66   77   76
  67   68   79   78
  68   69   80   79
  69   70   81   80
  70   71   82   81
  71   72   83   82
  72   73   84   83
  73   74   85   84
  74   75   86   85
  75   76   87   86
  76   77   88   87
  78   79   90   89
  79   80   91   90
  80   81   92   91
  81   82   93   92
  82   83   94   93
  83   84   95   94
  84   85   96   95
  85   86   97   96
  86   87   98   97
  87   88   99   98
  89   90  101  100
  90   91  102  101
  91   92  103  102
  92   93  104  103
  93   94  105  104
  94   95  106  105
  95   96  107  106
  96   97  108  107
  97   98  109  108
  98   99  110  109
 100  101  112  111
 101  102  113  112
 102  103  114  113
 103  104  115  114
 104  105  116  115
 105  106  117  116
 106  107  118  117
 107  108  119  118
 108  109  120  119
 109  110  121  120
COMP GROU 3 'plate' LECT 1 PAS 1 100 TERM
            'pres'  LECT 101 PAS 1 200 TERM
            'cplat' LECT plate TERM COND BOX X0 2.4 Y0 2.4 Z0 -1
                                         DX 5.2 DY 5.2 DZ  2
     EPAI 1.E-1 LECT plate _q4gs TERM
     NGRO 2 'cent' LECT plate TERM COND NEAR POIN 5 5 0
            'clamp' LECT 1 PAS 1 11 111 PAS 1 121
                         12 PAS 11 100
                         22 PAS 11 110 TERM
     COUL VERT LECT plate TERM
          JAUN LECT pres TERM
MATE LINE RO 8000. YOUN 2.E11 NU 0.0
          LECT plate _q4gs TERM
     IMPE PIMP RO 8000 PRES 10.E5 PREF 0
          TABP 2 0 1 100 1
          LECT pres _cl3d TERM
LINK COUP SPLT NONE
     BLOQ 123456 LECT clamp TERM
INIT ADAP SPLI LEVE 3 LECT cplat TERM
ECRI COOR DEPL VITE ACCE FINT FEXT CONT ECRO TFRE 1.E-3
     POIN LECT 1 TERM
     ELEM LECT 1 TERM
     FICH ALIC TEMP FREQ 1 POIN LECT cent TERM
OPTI NOTE STEP LIBR
 LNKS STAT
 log 1
 ADAP RCON DHAN
CALC TINI 0. TEND 60.0E-3
*=================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
RESU ALIC TEMP GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dx_cent' DEPL COMP 1 NOEU LECT cent TERM
COUR 2 'dy_cent' DEPL COMP 2 NOEU LECT cent TERM
COUR 3 'dz_cent' DEPL COMP 3 NOEU LECT cent TERM
TRAC 1 2 3 AXES 1.0 'DISPL. [M]' YZER
LIST 1 2 3 AXES 1.0 'DISPL. [M]' YZER
RCOU 11 'dx_cent' FICH 'q4gs14.pun' RENA 'dx_cent_14'
RCOU 12 'dy_cent' FICH 'q4gs14.pun' RENA 'dy_cent_14'
RCOU 13 'dz_cent' FICH 'q4gs14.pun' RENA 'dz_cent_14'
TRAC 3 13 AXES 1.0 'DISPL. [M]' YZER
COLO NOIR ROUG
*=================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
RESU ALIC TEMP GARD PSCR
SORT ARRE TEMP 2.4E-2 ! Max displacement occurs at this time
QUAL DEPL COMP 1 LECT cent TERM REFE  0.00000E+0 TOLE 1.E-3
     DEPL COMP 2 LECT cent TERM REFE  0.00000E+0 TOLE 1.E-3
     DEPL COMP 3 LECT cent TERM REFE  3.74479E-1 TOLE 1.E-2
*=================================================================
FIN
```

q4gs17.epx

```
Q4GS17
ECHO
!CONV win
LAGR TRID
DIME ADAP NPOI 120 Q4GS 144 CL3D 144 ENDA TERM
GEOM LIBR POIN 121 Q4GS 100 CL3D 100 TERM
  0.0  0.0  0.0
  1.0  0.0  0.0
  2.0  0.0  0.0
  3.0  0.0  0.0
  4.0  0.0  0.0
  5.0  0.0  0.0
  6.0  0.0  0.0
  7.0  0.0  0.0
  8.0  0.0  0.0
  9.0  0.0  0.0
 10.0  0.0  0.0
  0.0  1.0  0.0
  1.0  1.0  0.0
  2.0  1.0  0.0
  3.0  1.0  0.0
  4.0  1.0  0.0
  5.0  1.0  0.0
  6.0  1.0  0.0
  7.0  1.0  0.0
  8.0  1.0  0.0
  9.0  1.0  0.0
 10.0  1.0  0.0
  0.0  2.0  0.0
  1.0  2.0  0.0
  2.0  2.0  0.0
  3.0  2.0  0.0
  4.0  2.0  0.0
  5.0  2.0  0.0
  6.0  2.0  0.0
  7.0  2.0  0.0
  8.0  2.0  0.0
  9.0  2.0  0.0
 10.0  2.0  0.0
  0.0  3.0  0.0
  1.0  3.0  0.0
  2.0  3.0  0.0
  3.0  3.0  0.0
```

```
  4.0  3.0  0.0
  5.0  3.0  0.0
  6.0  3.0  0.0
  7.0  3.0  0.0
  8.0  3.0  0.0
  9.0  3.0  0.0
 10.0  3.0  0.0
  0.0  4.0  0.0
  1.0  4.0  0.0
  2.0  4.0  0.0
  3.0  4.0  0.0
  4.0  4.0  0.0
  5.0  4.0  0.0
  6.0  4.0  0.0
  7.0  4.0  0.0
  8.0  4.0  0.0
  9.0  4.0  0.0
 10.0  4.0  0.0
  0.0  5.0  0.0
  1.0  5.0  0.0
  2.0  5.0  0.0
  3.0  5.0  0.0
  4.0  5.0  0.0
  5.0  5.0  0.0
  6.0  5.0  0.0
  7.0  5.0  0.0
  8.0  5.0  0.0
  9.0  5.0  0.0
 10.0  5.0  0.0
  0.0  6.0  0.0
  1.0  6.0  0.0
  2.0  6.0  0.0
  3.0  6.0  0.0
  4.0  6.0  0.0
  5.0  6.0  0.0
  6.0  6.0  0.0
  7.0  6.0  0.0
  8.0  6.0  0.0
  9.0  6.0  0.0
 10.0  6.0  0.0
  0.0  7.0  0.0
  1.0  7.0  0.0
  2.0  7.0  0.0
  3.0  7.0  0.0
  4.0  7.0  0.0
  5.0  7.0  0.0
  6.0  7.0  0.0
  7.0  7.0  0.0
  8.0  7.0  0.0
  9.0  7.0  0.0
 10.0  7.0  0.0
  0.0  8.0  0.0
  1.0  8.0  0.0
  2.0  8.0  0.0
  3.0  8.0  0.0
  4.0  8.0  0.0
  5.0  8.0  0.0
  6.0  8.0  0.0
  7.0  8.0  0.0
  8.0  8.0  0.0
  9.0  8.0  0.0
 10.0  8.0  0.0
  0.0  9.0  0.0
  1.0  9.0  0.0
  2.0  9.0  0.0
  3.0  9.0  0.0
  4.0  9.0  0.0
  5.0  9.0  0.0
  6.0  9.0  0.0
  7.0  9.0  0.0
  8.0  9.0  0.0
  9.0  9.0  0.0
 10.0  9.0  0.0
  0.0 10.0  0.0
  1.0 10.0  0.0
  2.0 10.0  0.0
  3.0 10.0  0.0
  4.0 10.0  0.0
  5.0 10.0  0.0
  6.0 10.0  0.0
  7.0 10.0  0.0
  8.0 10.0  0.0
  9.0 10.0  0.0
 10.0 10.0  0.0
    1    2   13   12
    2    3   14   13
    3    4   15   14
    4    5   16   15
    5    6   17   16
    6    7   18   17
    7    8   19   18
    8    9   20   19
    9   10   21   20
   10   11   22   21
   12   13   24   23
   13   14   25   24
   14   15   26   25
   15   16   27   26
   16   17   28   27
   17   18   29   28
   18   19   30   29
   19   20   31   30
   20   21   32   31
   21   22   33   32
   23   24   35   34
   24   25   36   35
   25   26   37   36
   26   27   38   37
   27   28   39   38
   28   29   40   39
   29   30   41   40
   30   31   42   41
   31   32   43   42
   32   33   44   43
   34   35   46   45
   35   36   47   46
   36   37   48   47
   37   38   49   48
```

```
   38   39   50   49
   39   40   51   50
   40   41   52   51
   41   42   53   52
   42   43   54   53
   43   44   55   54
   45   46   57   56
   46   47   58   57
   47   48   59   58
   48   49   60   59
   49   50   61   60
   50   51   62   61
   51   52   63   62
   52   53   64   63
   53   54   65   64
   54   55   66   65
   56   57   68   67
   57   58   69   68
   58   59   70   69
   59   60   71   70
   60   61   72   71
   61   62   73   72
   62   63   74   73
   63   64   75   74
   64   65   76   75
   65   66   77   76
   67   68   79   78
   68   69   80   79
   69   70   81   80
   70   71   82   81
   71   72   83   82
   72   73   84   83
   73   74   85   84
   74   75   86   85
   75   76   87   86
   76   77   88   87
   78   79   90   89
   79   80   91   90
   80   81   92   91
   81   82   93   92
   82   83   94   93
   83   84   95   94
   84   85   96   95
   85   86   97   96
   86   87   98   97
   87   88   99   98
   89   90  101  100
   90   91  102  101
   91   92  103  102
   92   93  104  103
   93   94  105  104
   94   95  106  105
   95   96  107  106
   96   97  108  107
   97   98  109  108
   98   99  110  109
  100  101  112  111
  101  102  113  112
  102  103  114  113
  103  104  115  114
  104  105  116  115
  105  106  117  116
  106  107  118  117
  107  108  119  118
  108  109  120  119
  109  110  121  120
    1    2   13   12
    2    3   14   13
    3    4   15   14
    4    5   16   15
    5    6   17   16
    6    7   18   17
    7    8   19   18
    8    9   20   19
    9   10   21   20
   10   11   22   21
   12   13   24   23
   13   14   25   24
   14   15   26   25
   15   16   27   26
   16   17   28   27
   17   18   29   28
   18   19   30   29
   19   20   31   30
   20   21   32   31
   21   22   33   32
   23   24   35   34
   24   25   36   35
   25   26   37   36
   26   27   38   37
   27   28   39   38
   28   29   40   39
   29   30   41   40
   30   31   42   41
   31   32   43   42
   32   33   44   43
   34   35   46   45
   35   36   47   46
   36   37   48   47
   37   38   49   48
   38   39   50   49
   39   40   51   50
   40   41   52   51
   41   42   53   52
   42   43   54   53
   43   44   55   54
   45   46   57   56
   46   47   58   57
   47   48   59   58
   48   49   60   59
   49   50   61   60
   50   51   62   61
   51   52   63   62
   52   53   64   63
   53   54   65   64
   54   55   66   65
   56   57   68   67
   57   58   69   68
```

```
   58   59   70   69
   59   60   71   70
   60   61   72   71
   61   62   73   72
   62   63   74   73
   63   64   75   74
   64   65   76   75
   65   66   77   76
   67   68   79   78
   68   69   80   79
   69   70   81   80
   70   71   82   81
   71   72   83   82
   72   73   84   83
   73   74   85   84
   74   75   86   85
   75   76   87   86
   76   77   88   87
   78   79   90   89
   79   80   91   90
   80   81   92   91
   81   82   93   92
   82   83   94   93
   83   84   95   94
   84   85   96   95
   85   86   97   96
   86   87   98   97
   87   88   99   98
   89   90  101  100
   90   91  102  101
   91   92  103  102
   92   93  104  103
   93   94  105  104
   94   95  106  105
   95   96  107  106
   96   97  108  107
   97   98  109  108
   98   99  110  109
  100  101  112  111
  101  102  113  112
  102  103  114  113
  103  104  115  114
  104  105  116  115
  105  106  117  116
  106  107  118  117
  107  108  119  118
  108  109  120  119
  109  110  121  120
COMP GROU 3 'plate' LECT 1 PAS 1 100 TERM
            'pres'  LECT 101 PAS 1 200 TERM
            'cplat' LECT plate TERM COND BOX X0 2.4 Y0 2.4 Z0 -1
                                         DX 5.2 DY 5.2 DZ  2
     EPAI 1.E-1 LECT plate _q4gs TERM
     NGRO 2 'cent' LECT plate TERM COND NEAR POIN 5 5 0
            'clamp' LECT 1 PAS 1 11 111 PAS 1 121
                         12 PAS 11 100
                         22 PAS 11 110 TERM
     COUL VERT LECT plate TERM
          JAUN LECT pres TERM
MATE LINE RO 8000. YOUN 2.E11 NU 0.0
          LECT plate _q4gs TERM
     IMPE PIMP RO 8000 PRES 10.E5 PREF 0
          TABP 2 0 1 100 1
          LECT pres _cl3d TERM
LINK COUP SPLT NONE
     BLOQ 123456 LECT clamp TERM
INIT ADAP SPLI LEVE 2 LECT cplat TERM
ECRI COOR DEPL VITE ACCE FINT FEXT CONT ECRO TFRE 1.E-3
     POIN LECT 1 TERM
     ELEM LECT 1 TERM
     FICH ALIC TEMP FREQ 1 POIN LECT cent TERM
OPTI NOTE STEP LIBR
 LNKS STAT
 log 1
 ADAP WHAN
CALC TINI 0. TEND 60.0E-3
*=================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
RESU ALIC TEMP GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dx_cent' DEPL COMP 1 NOEU LECT cent TERM
COUR 2 'dy_cent' DEPL COMP 2 NOEU LECT cent TERM
COUR 3 'dz_cent' DEPL COMP 3 NOEU LECT cent TERM
TRAC 1 2 3 AXES 1.0 'DISPL. [M]' YZER
LIST 1 2 3 AXES 1.0 'DISPL. [M]' YZER
RCOU 11 'dx_cent' FICH 'q4gs11.pun' RENA 'dx_cent_11'
RCOU 12 'dy_cent' FICH 'q4gs11.pun' RENA 'dy_cent_11'
RCOU 13 'dz_cent' FICH 'q4gs11.pun' RENA 'dz_cent_11'
TRAC 3 13 AXES 1.0 'DISPL. [M]' YZER
COLO NOIR ROUG
*=================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
RESU ALIC TEMP GARD PSCR
SORT ARRE TEMP 2.4E-2 ! Max displacement occurs at this time
QUAL DEPL COMP 1 LECT cent TERM REFE  0.00000E+0 TOLE 1.E-3
     DEPL COMP 2 LECT cent TERM REFE  0.00000E+0 TOLE 1.E-3
     DEPL COMP 3 LECT cent TERM REFE  3.72745E-1 TOLE 1.E-2
*=================================================================
FIN
```

q4gs18.epx

```
Q4GS18
ECHO
!CONV win
LAGR TRID
DIME ADAP NPOI 652 Q4GS 816 CL3D 816 ENDA TERM
GEOM LIBR POIN 121 Q4GS 100 CL3D 100 TERM
  0.0  0.0  0.0
  1.0  0.0  0.0
  2.0  0.0  0.0
  3.0  0.0  0.0
  4.0  0.0  0.0
  5.0  0.0  0.0
  6.0  0.0  0.0
  7.0  0.0  0.0
  8.0  0.0  0.0
  9.0  0.0  0.0
 10.0  0.0  0.0
  0.0  1.0  0.0
  1.0  1.0  0.0
  2.0  1.0  0.0
  3.0  1.0  0.0
  4.0  1.0  0.0
  5.0  1.0  0.0
  6.0  1.0  0.0
  7.0  1.0  0.0
  8.0  1.0  0.0
  9.0  1.0  0.0
 10.0  1.0  0.0
  0.0  2.0  0.0
  1.0  2.0  0.0
  2.0  2.0  0.0
  3.0  2.0  0.0
  4.0  2.0  0.0
  5.0  2.0  0.0
  6.0  2.0  0.0
  7.0  2.0  0.0
  8.0  2.0  0.0
  9.0  2.0  0.0
 10.0  2.0  0.0
  0.0  3.0  0.0
  1.0  3.0  0.0
  2.0  3.0  0.0
  3.0  3.0  0.0
  4.0  3.0  0.0
  5.0  3.0  0.0
  6.0  3.0  0.0
  7.0  3.0  0.0
  8.0  3.0  0.0
  9.0  3.0  0.0
 10.0  3.0  0.0
  0.0  4.0  0.0
  1.0  4.0  0.0
  2.0  4.0  0.0
  3.0  4.0  0.0
  4.0  4.0  0.0
  5.0  4.0  0.0
  6.0  4.0  0.0
  7.0  4.0  0.0
  8.0  4.0  0.0
  9.0  4.0  0.0
 10.0  4.0  0.0
  0.0  5.0  0.0
  1.0  5.0  0.0
  2.0  5.0  0.0
  3.0  5.0  0.0
  4.0  5.0  0.0
  5.0  5.0  0.0
  6.0  5.0  0.0
  7.0  5.0  0.0
  8.0  5.0  0.0
  9.0  5.0  0.0
 10.0  5.0  0.0
  0.0  6.0  0.0
  1.0  6.0  0.0
  2.0  6.0  0.0
  3.0  6.0  0.0
  4.0  6.0  0.0
  5.0  6.0  0.0
  6.0  6.0  0.0
  7.0  6.0  0.0
  8.0  6.0  0.0
  9.0  6.0  0.0
 10.0  6.0  0.0
  0.0  7.0  0.0
  1.0  7.0  0.0
  2.0  7.0  0.0
  3.0  7.0  0.0
  4.0  7.0  0.0
  5.0  7.0  0.0
  6.0  7.0  0.0
  7.0  7.0  0.0
  8.0  7.0  0.0
  9.0  7.0  0.0
 10.0  7.0  0.0
  0.0  8.0  0.0
  1.0  8.0  0.0
  2.0  8.0  0.0
  3.0  8.0  0.0
  4.0  8.0  0.0
  5.0  8.0  0.0
  6.0  8.0  0.0
  7.0  8.0  0.0
  8.0  8.0  0.0
  9.0  8.0  0.0
 10.0  8.0  0.0
  0.0  9.0  0.0
  1.0  9.0  0.0
  2.0  9.0  0.0
  3.0  9.0  0.0
  4.0  9.0  0.0
  5.0  9.0  0.0
  6.0  9.0  0.0
  7.0  9.0  0.0
  8.0  9.0  0.0
  9.0  9.0  0.0
 10.0  9.0  0.0
  0.0 10.0  0.0
  1.0 10.0  0.0
  2.0 10.0  0.0
  3.0 10.0  0.0
  4.0 10.0  0.0
  5.0 10.0  0.0
  6.0 10.0  0.0
  7.0 10.0  0.0
  8.0 10.0  0.0
  9.0 10.0  0.0
 10.0 10.0  0.0
```

```
   1    2   13   12
   2    3   14   13
   3    4   15   14
   4    5   16   15
   5    6   17   16
   6    7   18   17
   7    8   19   18
   8    9   20   19
   9   10   21   20
  10   11   22   21
  12   13   24   23
  13   14   25   24
  14   15   26   25
  15   16   27   26
  16   17   28   27
  17   18   29   28
  18   19   30   29
  19   20   31   30
  20   21   32   31
  21   22   33   32
  23   24   35   34
  24   25   36   35
  25   26   37   36
  26   27   38   37
  27   28   39   38
  28   29   40   39
  29   30   41   40
  30   31   42   41
  31   32   43   42
  32   33   44   43
  34   35   46   45
  35   36   47   46
  36   37   48   47
  37   38   49   48
  38   39   50   49
  39   40   51   50
  40   41   52   51
  41   42   53   52
  42   43   54   53
  43   44   55   54
  45   46   57   56
  46   47   58   57
  47   48   59   58
  48   49   60   59
  49   50   61   60
  50   51   62   61
  51   52   63   62
  52   53   64   63
  53   54   65   64
  54   55   66   65
  56   57   68   67
  57   58   69   68
  58   59   70   69
  59   60   71   70
  60   61   72   71
  61   62   73   72
  62   63   74   73
  63   64   75   74
  64   65   76   75
  65   66   77   76
  67   68   79   78
  68   69   80   79
  69   70   81   80
  70   71   82   81
  71   72   83   82
  72   73   84   83
  73   74   85   84
  74   75   86   85
  75   76   87   86
  76   77   88   87
  78   79   90   89
  79   80   91   90
  80   81   92   91
  81   82   93   92
  82   83   94   93
  83   84   95   94
  84   85   96   95
  85   86   97   96
  86   87   98   97
  87   88   99   98
  89   90  101  100
  90   91  102  101
  91   92  103  102
  92   93  104  103
  93   94  105  104
  94   95  106  105
  95   96  107  106
  96   97  108  107
  97   98  109  108
  98   99  110  109
 100  101  112  111
 101  102  113  112
 102  103  114  113
 103  104  115  114
 104  105  116  115
 105  106  117  116
 106  107  118  117
 107  108  119  118
 108  109  120  119
 109  110  121  120
   1    2   13   12
   2    3   14   13
   3    4   15   14
   4    5   16   15
   5    6   17   16
   6    7   18   17
   7    8   19   18
   8    9   20   19
   9   10   21   20
  10   11   22   21
  12   13   24   23
  13   14   25   24
  14   15   26   25
  15   16   27   26
  16   17   28   27
  17   18   29   28
  18   19   30   29
  19   20   31   30
  20   21   32   31
  21   22   33   32
  23   24   35   34
  24   25   36   35
  25   26   37   36
  26   27   38   37
  27   28   39   38
  28   29   40   39
  29   30   41   40
  30   31   42   41
  31   32   43   42
  32   33   44   43
  34   35   46   45
  35   36   47   46
  36   37   48   47
  37   38   49   48
  38   39   50   49
  39   40   51   50
  40   41   52   51
  41   42   53   52
  42   43   54   53
  43   44   55   54
  45   46   57   56
  46   47   58   57
  47   48   59   58
  48   49   60   59
  49   50   61   60
  50   51   62   61
  51   52   63   62
  52   53   64   63
  53   54   65   64
  54   55   66   65
  56   57   68   67
  57   58   69   68
  58   59   70   69
  59   60   71   70
  60   61   72   71
  61   62   73   72
  62   63   74   73
  63   64   75   74
  64   65   76   75
  65   66   77   76
  67   68   79   78
  68   69   80   79
  69   70   81   80
  70   71   82   81
  71   72   83   82
  72   73   84   83
  73   74   85   84
  74   75   86   85
  75   76   87   86
  76   77   88   87
  78   79   90   89
  79   80   91   90
  80   81   92   91
  81   82   93   92
  82   83   94   93
  83   84   95   94
  84   85   96   95
  85   86   97   96
  86   87   98   97
  87   88   99   98
  89   90  101  100
  90   91  102  101
  91   92  103  102
  92   93  104  103
  93   94  105  104
  94   95  106  105
  95   96  107  106
  96   97  108  107
  97   98  109  108
  98   99  110  109
 100  101  112  111
 101  102  113  112
 102  103  114  113
 103  104  115  114
 104  105  116  115
 105  106  117  116
 106  107  118  117
 107  108  119  118
 108  109  120  119
 109  110  121  120
COMP GROU 3 'plate' LECT 1 PAS 1 100 TERM
              'pres'  LECT 101 PAS 1 200 TERM
              'cplat' LECT plate TERM COND BOX X0 2.4 Y0 2.4 Z0 -1
                                                  DX 5.2 DY 5.2 DZ  2
     EPAI 1.E-1 LECT plate _q4gs TERM
     NGRO 2 'cent' LECT plate TERM COND NEAR POIN 5 5 0
              'clamp' LECT 1 PAS 1 11 111 PAS 1 121
                           12 PAS 11 100
                           22 PAS 11 110 TERM
     COUL VERT LECT plate TERM
          JAUN LECT pres TERM
MATE LINE RO 8000. YOUN 2.E11 NU 0.0
          LECT plate _q4gs TERM
     IMPE PIMP RO 8000 PRES 10.E5 PREF 0
          TABP 2 0 1 100 1
          LECT pres _cl3d TERM
LINK COUP SPLT NONE
     BLOQ 123456 LECT clamp TERM
INIT ADAP SPLI LEVE 3 LECT cplat TERM
ECRI COOR DEPL VITE ACCE FINT FEXT CONT ECRO TFRE 1.E-3
     POIN LECT 1 TERM
     ELEM LECT 1 TERM
     FICH ALIC TEMP FREQ 1 POIN LECT cent TERM
OPTI NOTE STEP LIBR
 LNKS STAT
 log 1
 ADAP RCON WHAN
CALC TINI 0. TEND 60.0E-3
*=============================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
RESU ALIC TEMP GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dx_cent' DEPL COMP 1 NOEU LECT cent TERM
```

```
COUR 2 'dy_cent' DEPL COMP 2 NOEU LECT cent TERM
COUR 3 'dz_cent' DEPL COMP 3 NOEU LECT cent TERM
TRAC 1 2 3 AXES 1.0 'DISPL. [M]' YZER
LIST 1 2 3 AXES 1.0 'DISPL. [M]' YZER
RCOU 11 'dx_cent' FICH 'q4gs14.pun' RENA 'dx_cent_14'
RCOU 12 'dy_cent' FICH 'q4gs14.pun' RENA 'dy_cent_14'
RCOU 13 'dz_cent' FICH 'q4gs14.pun' RENA 'dz_cent_14'
TRAC 3 13 AXES 1.0 'DISPL. [M]' YZER
COLO NOIR ROUG
*================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
RESU ALIC TEMP GARD PSCR
SORT ARRE TEMP 2.4E-2 ! Max displacement occurs at this time
QUAL DEPL COMP 1 LECT cent TERM REFE  0.00000E+0 TOLE 1.E-3
     DEPL COMP 2 LECT cent TERM REFE  0.00000E+0 TOLE 1.E-3
     DEPL COMP 3 LECT cent TERM REFE  3.74479E-1 TOLE 1.E-2
*================================================================
FIN
```

tntl01.epx

```
TNTL01
ECHO
 CONV WIN
LAGR CPLA
DIME ADAP NPOI 14 Q41L 12 ENDA TERM
opti dump dpma
GEOM LIBR POIN 9 Q41L 4 TERM
  0 0  1 0  2 0
  0 1  1 1  2 1
  0 2  1 2  2 2
  1 2 5 4
  2 3 6 5
  4 5 8 7
  5 6 9 8
COMP GROU 1 'stru' LECT 1 PAS 1 4 TERM
     EPAI 0.01 LECT stru _q41l TERM
MATE VM23 RO 8000. YOUN 2.D11 NU 0.3 ELAS 2.E11
          TRAC 1 2.D11 1.0
          LECT stru _q41l TERM
LINK COUP ! mandatory for adaptivity
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI NOTE LOG 1
     ADAP DUMP STAT CHEC
     LNKS DUMP STAT DIAG
CALC TINI 0. TEND 1.0 NMAX 7
*-------------------------------------------------------------------
PLAY
CAME   1 EYE   1.00000E+00  1.00000E+00  7.07107E+00
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  1.00000E+00  1.00000E+00  0.00000E+00
!RSPHERE:  1.41421E+00
!RADIUS :  7.07107E+00
!ASPECT :  1.00000E+00
!NEAR   :  5.51543E+00
!FAR    :  9.89949E+00
SLER CAM1 1 NFRA 1
FREQ 1
SCEN OBJE SELV HANG
     GEOM NAVI FREE
          FACE HFRO
          POIN SPHE 1
     TEXT NODE ELEM
     COLO PAPE
TRAC OFFS FICH BMP REND
GO
ADAP SPLI 2 TERM
TRAC OFFS FICH BMP REND
GO
ADAP SPLI 4 TERM
TRAC OFFS FICH BMP REND
GO
ADAP SPLI 8 TERM
TRAC OFFS FICH BMP REND
GO
ADAP USPL 8 TERM
TRAC OFFS FICH BMP REND
GO
ADAP USPL 4 TERM
TRAC OFFS FICH BMP REND
GO
ADAP USPL 2 TERM
TRAC OFFS FICH BMP REND
GO
ENDPLAY
*-------------------------------------------------------------------
FIN
```

twad12.epx

```
TWAD12
ECHO
!CONV win
LAGR CPLA
DIME
  FORC 2 TABL 1 2
  ADAP NPOI 182 Q41L 208 CL22 14 ENDA
TERM
GEOM LIBR POIN 22 Q41L 10 CL22 1 TERM
 0.0 0.0  0.1 0.0  0.2 0.0  0.3 0.0  0.4 0.0  0.5 0.0
          0.6 0.0  0.7 0.0  0.8 0.0  0.9 0.0  1.0 0.0
 0.0 0.1  0.1 0.1  0.2 0.1  0.3 0.1  0.4 0.1  0.5 0.1
          0.6 0.1  0.7 0.1  0.8 0.1  0.9 0.1  1.0 0.1
 1 2 13 12
 2 3 14 13
 3 4 15 14
 4 5 16 15
 5 6 17 16
 6 7 18 17
 7 8 19 18
 8 9 20 19
 9 10 21 20
 10 11 22 21
 12 1
COMP GROU 2 'bar'  LECT 1 PAS 1 10 TERM
            'clpr' LECT 11 TERM
     NGRO 5 'p0'   LECT 1  TERM
            'p0p'  LECT 12 TERM
            'pmid' LECT 6  TERM
            'p1'   LECT 11 TERM
            'p1p'  LECT 22 TERM
     EPAI 1.E-2 LECT bar _q41l TERM
WAVE 2 PLAN X 0 Y 0 NX 1 NY 0 T0 0 C 5000 MAXL 4 H1 0.15 H2 0.5
       PLAN X 1 Y 0 NX -1 NY 0 T0 0.2E-3 C 5000 MAXL 4 H1 0.15 H2 0.5
MATE VM23 RO 8000. YOUN 2.E11 NU 0.0 ELAS 2.E11
          TRAC 1 2.E11 1.D0
          LECT bar _q41l TERM
     IMPE PIMP RO 8000. PRES -1.E6
          LECT clpr _cl22 TERM
ECRI COOR DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO
     TFRE 1.E-3
     FICH ALIC FREQ 1
LINK COUP BLOQ 1 LECT p1 p1p TERM
OPTI NOTE STEP LIBR
 LOG 1 DPMA LNKS STAT
CALC TINI 0. TEND 1.E-3
*================================================================
PLAY
CAME   1 EYE   5.00000E-01  5.00000E-02  7.03491E-01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS SIZE 1548 392 FICH AVI NOCL NFTO 161 FPS 25 KFRE 10
          COMP -1
          OBJE LECT bar TERM
          REND
FREQ 1
GOTR LOOP 159 OFFS SIZE 1548 392 FICH AVI CONT NOCL
          OBJE LECT bar TERM
          REND
GO
TRAC OFFS SIZE 1548 392 FICH AVI CONT
          OBJE LECT bar TERM
          REND
ENDPLAY
*================================================================
SUIT
Animation from alice file
ECHO
RESU ALIC GARD PSCR
SORT VISU NSTO 1
PLAY
CAME   1 EYE   5.00000E-01  5.00000E-02  7.03491E-01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
SCEN GEOM NAVI FREE
     ISO  FILL FIEL VITE SCAL USER PROG 0.20 PAS 0.20 2.80 TERM
          SUPP LECT bar TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS SIZE 1548 392 FICH AVI NOCL NFTO 161 FPS 25 KFRE 10
          COMP -1
          OBJE LECT bar TERM
          REND
FREQ 1
GOTR LOOP 159 OFFS SIZE 1548 392 FICH AVI CONT NOCL
          OBJE LECT bar TERM
          REND
GO
TRAC OFFS SIZE 1548 392 FICH AVI CONT
          OBJE LECT bar TERM
          REND
ENDPLAY
*================================================================
SUIT
Post-treatment (time curves from alice file)
ECHO
RESU ALIC GARD PSCR
SORT GRAP
PERFO 'twad12.pun'
AXTE 1.0 'Time [s]'
COUR  1 'dx_p0'   DEPL COMP 1 NOEU LECT p0   TERM
COUR  2 'dx_pmid' DEPL COMP 1 NOEU LECT pmid TERM
COUR  3 'dx_p1'   DEPL COMP 1 NOEU LECT p1   TERM
COUR  4 'vx_p0'   VITE COMP 1 NOEU LECT p0   TERM
COUR  5 'vx_pmid' VITE COMP 1 NOEU LECT pmid TERM
COUR  6 'vx_p1'   VITE COMP 1 NOEU LECT p1   TERM
TRAC 1 2 3 AXES 1.0 'DISPL. [M]'
TRAC 4 5 6 AXES 1.0 'VELOC. [M/S]'
LIST 1 2 3 AXES 1.0 'DISPL. [M]'
LIST 4 5 6 AXES 1.0 'VELOC. [M/S]'
QUAL DEPL COMP 1 LECT p0   TERM REFE  5.39339E-4 TOLE 5.E-3
     DEPL COMP 1 LECT pmid TERM REFE  2.87151E-4 TOLE 5.E-3
     DEPL COMP 1 LECT p1   TERM REFE  0.00000E+0 TOLE 5.E-3
     VITE COMP 1 LECT p0   TERM REFE  2.03415E+0 TOLE 5.E-3
     VITE COMP 1 LECT pmid TERM REFE  2.56695E+0 TOLE 5.E-3
     VITE COMP 1 LECT p1   TERM REFE  0.00000E+0 TOLE 5.E-3
*================================================================
FIN
```

twad62.epx

```
TWAD62
ECHO
!CONV win
LAGR CPLA
DIME
  FORC 2 TABL 1 2
  ADAP NPOI 182 Q41L 208 CL22 14 ENDA
TERM
GEOM LIBR POIN 22 Q41L 10 CL22 1 TERM
 0.0 0.0  0.1 0.0  0.2 0.0  0.3 0.0  0.4 0.0  0.5 0.0
          0.6 0.0  0.7 0.0  0.8 0.0  0.9 0.0  1.0 0.0
 0.0 0.1  0.1 0.1  0.2 0.1  0.3 0.1  0.4 0.1  0.5 0.1
          0.6 0.1  0.7 0.1  0.8 0.1  0.9 0.1  1.0 0.1
 1 2 13 12
 2 3 14 13
 3 4 15 14
 4 5 16 15
 5 6 17 16
 6 7 18 17
 7 8 19 18
 8 9 20 19
 9 10 21 20
 10 11 22 21
 12 1
COMP GROU 2 'bar'  LECT 1 PAS 1 10 TERM
            'clpr' LECT 11 TERM
     NGRO 5 'p0'   LECT 1  TERM
            'p0p'  LECT 12 TERM
            'pmid' LECT 6  TERM
            'p1'   LECT 11 TERM
            'p1p'  LECT 22 TERM
     EPAI 1.E-2 LECT bar _q41l TERM
WAVE 2 PLAN X 0 Y 0 NX 1 NY 0 T0 0 C 5000 MAXL 4 H1 0.15 H2 0.5
       PLAN X 1 Y 0 NX -1 NY 0 T0 0.2E-3 C 5000 MAXL 4 H1 0.15 H2 0.5
MATE VM23 RO 8000. YOUN 2.E11 NU 0.0 ELAS 2.E11
          TRAC 1 2.E11 1.D0
          LECT bar _q41l TERM
     IMPE PIMP RO 8000. PRES -1.E6
          LECT clpr _cl22 TERM
ECRI COOR DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO
     TFRE 1.E-3
     FICH ALIC FREQ 1
LINK COUP BLOQ 1 LECT p1 p1p TERM
OPTI NOTE STEP LIBR
 LOG 1 DPMA LNKS STAT
 ADAP PHAN CD 2.E11
CALC TINI 0. TEND 1.E-3
*=================================================================
PLAY
CAME   1 EYE   5.00000E-01  5.00000E-02  7.03491E-01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS SIZE 1548 392 FICH AVI NOCL NFTO 161 FPS 25 KFRE 10
          COMP -1
          OBJE LECT bar TERM
          REND
FREQ 1
GOTR LOOP 159 OFFS SIZE 1548 392 FICH AVI CONT NOCL
          OBJE LECT bar TERM
          REND
GO
TRAC OFFS SIZE 1548 392 FICH AVI CONT
          OBJE LECT bar TERM
          REND
ENDPLAY
*=================================================================
SUIT
Animation from alice file
ECHO
RESU ALIC GARD PSCR
SORT VISU NSTO 1
PLAY
CAME   1 EYE   5.00000E-01  5.00000E-02  7.03491E-01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
SCEN GEOM NAVI FREE
     ISO  FILL FIEL VITE SCAL USER PROG 0.20 PAS 0.20 2.80 TERM
          SUPP LECT bar TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS SIZE 1548 392 FICH AVI NOCL NFTO 161 FPS 25 KFRE 10
          COMP -1
          OBJE LECT bar TERM
          REND
FREQ 1
GOTR LOOP 159 OFFS SIZE 1548 392 FICH AVI CONT NOCL
          OBJE LECT bar TERM
          REND
GO
TRAC OFFS SIZE 1548 392 FICH AVI CONT
          OBJE LECT bar TERM
          REND
ENDPLAY
*=================================================================
SUIT
Post-treatment (time curves from alice file)
ECHO
RESU ALIC GARD PSCR
SORT GRAP
PERFO 'twad62.pun'
AXTE 1.0 'Time [s]'
COUR  1 'dx_p0'   DEPL COMP 1 NOEU LECT p0   TERM
COUR  2 'dx_pmid' DEPL COMP 1 NOEU LECT pmid TERM
COUR  3 'dx_p1'   DEPL COMP 1 NOEU LECT p1   TERM
COUR  4 'vx_p0'   VITE COMP 1 NOEU LECT p0   TERM
COUR  5 'vx_pmid' VITE COMP 1 NOEU LECT pmid TERM
COUR  6 'vx_p1'   VITE COMP 1 NOEU LECT p1   TERM
TRAC 1 2 3 AXES 1.0 'DISPL. [M]'
TRAC 4 5 6 AXES 1.0 'VELOC. [M/S]'
LIST 1 2 3 AXES 1.0 'DISPL. [M]'
LIST 4 5 6 AXES 1.0 'VELOC. [M/S]'
QUAL DEPL COMP 1 LECT p0   TERM REFE  5.39339E-4 TOLE 5.E-3
     DEPL COMP 1 LECT pmid TERM REFE  2.87151E-4 TOLE 5.E-3
     DEPL COMP 1 LECT p1   TERM REFE  0.00000E+0 TOLE 5.E-3
     VITE COMP 1 LECT p0   TERM REFE  2.03415E+0 TOLE 5.E-3
     VITE COMP 1 LECT pmid TERM REFE  2.56695E+0 TOLE 5.E-3
     VITE COMP 1 LECT p1   TERM REFE  0.00000E+0 TOLE 5.E-3
*=================================================================
FIN
```

twad63.epx

```
TWAD63
ECHO
!CONV win
LAGR CPLA
DIME
  FORC 2 TABL 1 2
  ADAP NPOI 182 Q41L 208 CL22 14 ENDA
TERM
GEOM LIBR POIN 22 Q41L 10 CL22 1 TERM
 0.0 0.0  0.1 0.0  0.2 0.0  0.3 0.0  0.4 0.0  0.5 0.0
          0.6 0.0  0.7 0.0  0.8 0.0  0.9 0.0  1.0 0.0
 0.0 0.1  0.1 0.1  0.2 0.1  0.3 0.1  0.4 0.1  0.5 0.1
          0.6 0.1  0.7 0.1  0.8 0.1  0.9 0.1  1.0 0.1
 1 2 13 12
 2 3 14 13
 3 4 15 14
 4 5 16 15
 5 6 17 16
 6 7 18 17
 7 8 19 18
 8 9 20 19
 9 10 21 20
 10 11 22 21
 12 1
COMP GROU 2 'bar'  LECT 1 PAS 1 10 TERM
            'clpr' LECT 11 TERM
     NGRO 5 'p0'   LECT 1  TERM
            'p0p'  LECT 12 TERM
            'pmid' LECT 6  TERM
            'p1'   LECT 11 TERM
            'p1p'  LECT 22 TERM
     EPAI 1.E-2 LECT bar _q41l TERM
WAVE 2 PLAN X 0 Y 0 NX 1 NY 0 T0 0 C 5000 MAXL 4 H1 0.15 H2 0.5
       PLAN X 1 Y 0 NX -1 NY 0 T0 0.2E-3 C 5000 MAXL 4 H1 0.15 H2 0.5
MATE VM23 RO 8000. YOUN 2.E11 NU 0.0 ELAS 2.E11
          TRAC 1 2.E11 1.D0
          LECT bar _q41l TERM
     IMPE PIMP RO 8000. PRES -1.E6
          LECT clpr _cl22 TERM
ECRI COOR DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO
     TFRE 1.E-3
     FICH ALIC FREQ 1
LINK COUP BLOQ 1 LECT p1 p1p TERM
OPTI NOTE STEP LIBR
 LOG 1 DPMA LNKS STAT
 ADAP PHAN CD 30.E9
CALC TINI 0. TEND 1.E-3
*=================================================================
PLAY
CAME   1 EYE   5.00000E-01  5.00000E-02  7.03491E-01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS SIZE 1548 392 FICH AVI NOCL NFTO 161 FPS 25 KFRE 10
          COMP -1
          OBJE LECT bar TERM
          REND
FREQ 1
GOTR LOOP 159 OFFS SIZE 1548 392 FICH AVI CONT NOCL
          OBJE LECT bar TERM
          REND
GO
TRAC OFFS SIZE 1548 392 FICH AVI CONT
          OBJE LECT bar TERM
          REND
ENDPLAY
*=================================================================
SUIT
Animation from alice file
ECHO
RESU ALIC GARD PSCR
SORT VISU NSTO 1
PLAY
CAME   1 EYE   5.00000E-01  5.00000E-02  7.03491E-01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
SCEN GEOM NAVI FREE
     ISO  FILL FIEL VITE SCAL USER PROG 0.20 PAS 0.20 2.80 TERM
          SUPP LECT bar TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS SIZE 1548 392 FICH AVI NOCL NFTO 161 FPS 25 KFRE 10
          COMP -1
          OBJE LECT bar TERM
          REND
FREQ 1
GOTR LOOP 159 OFFS SIZE 1548 392 FICH AVI CONT NOCL
          OBJE LECT bar TERM
          REND
```

```
GO
TRAC OFFS SIZE 1548 392 FICH AVI CONT
          OBJE LECT bar TERM
          REND
ENDPLAY
*=================================================================
SUIT
Post-treatment (time curves from alice file)
ECHO
RESU ALIC GARD PSCR
SORT GRAP
PERFO 'twad63.pun'
AXTE 1.0 'Time [s]'
COUR  1 'dx_p0'   DEPL COMP 1 NOEU LECT p0   TERM
COUR  2 'dx_pmid' DEPL COMP 1 NOEU LECT pmid TERM
COUR  3 'dx_p1'   DEPL COMP 1 NOEU LECT p1   TERM
COUR  4 'vx_p0'   VITE COMP 1 NOEU LECT p0   TERM
COUR  5 'vx_pmid' VITE COMP 1 NOEU LECT pmid TERM
COUR  6 'vx_p1'   VITE COMP 1 NOEU LECT p1   TERM
TRAC 1 2 3 AXES 1.0 'DISPL. [M]'
TRAC 4 5 6 AXES 1.0 'VELOC. [M/S]'
LIST 1 2 3 AXES 1.0 'DISPL. [M]'
LIST 4 5 6 AXES 1.0 'VELOC. [M/S]'
QUAL DEPL COMP 1 LECT p0   TERM REFE  5.39339E-4 TOLE 5.E-3
     DEPL COMP 1 LECT pmid TERM REFE  2.87151E-4 TOLE 5.E-3
     DEPL COMP 1 LECT p1   TERM REFE  0.00000E+0 TOLE 5.E-3
     VITE COMP 1 LECT p0   TERM REFE  2.03415E+0 TOLE 5.E-3
     VITE COMP 1 LECT pmid TERM REFE  2.56695E+0 TOLE 5.E-3
     VITE COMP 1 LECT p1   TERM REFE  0.00000E+0 TOLE 5.E-3
*=================================================================
FIN
```

twad64.epx

```
TWAD64
ECHO
!CONV win
LAGR CPLA
DIME
  FORC 2 TABL 1 2
  ADAP NPOI 182 Q41L 208 CL22 14 ENDA
TERM
GEOM LIBR POIN 22 Q41L 10 CL22 1 TERM
 0.0 0.0  0.1 0.0  0.2 0.0  0.3 0.0  0.4 0.0  0.5 0.0
          0.6 0.0  0.7 0.0  0.8 0.0  0.9 0.0  1.0 0.0
 0.0 0.1  0.1 0.1  0.2 0.1  0.3 0.1  0.4 0.1  0.5 0.1
          0.6 0.1  0.7 0.1  0.8 0.1  0.9 0.1  1.0 0.1
 1 2 13 12
 2 3 14 13
 3 4 15 14
 4 5 16 15
 5 6 17 16
 6 7 18 17
 7 8 19 18
 8 9 20 19
 9 10 21 20
 10 11 22 21
 12 1
COMP GROU 2 'bar'  LECT 1 PAS 1 10 TERM
            'clpr' LECT 11 TERM
     NGRO 5 'p0'   LECT 1  TERM
            'p0p'  LECT 12 TERM
            'pmid' LECT 6  TERM
            'p1'   LECT 11 TERM
            'p1p'  LECT 22 TERM
     EPAI 1.E-2 LECT bar _q41l TERM
WAVE 2 PLAN X 0 Y 0 NX 1 NY 0 T0 0 C 5000 MAXL 4 H1 0.15 H2 0.5
       PLAN X 1 Y 0 NX -1 NY 0 T0 0.2E-3 C 5000 MAXL 4 H1 0.15 H2 0.5
MATE VM23 RO 8000. YOUN 2.E11 NU 0.0 ELAS 2.E11
          TRAC 1 2.E11 1.D0
          LECT bar _q41l TERM
     IMPE PIMP RO 8000. PRES -1.E6
          LECT clpr _cl22 TERM
ECRI COOR DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO
     TFRE 1.E-3
     FICH ALIC FREQ 1
LINK COUP BLOQ 1 LECT p1 p1p TERM
OPTI NOTE STEP LIBR
 LOG 1 DPMA LNKS STAT
 ADAP PHAN CD 3.E9
CALC TINI 0. TEND 1.E-3
*=================================================================
PLAY
CAME   1 EYE   5.00000E-01  5.00000E-02  7.03491E-01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS SIZE 1548 392 FICH AVI NOCL NFTO 161 FPS 25 KFRE 10
          COMP -1
          OBJE LECT bar TERM
          REND
FREQ 1
GOTR LOOP 159 OFFS SIZE 1548 392 FICH AVI CONT NOCL
          OBJE LECT bar TERM
          REND
GO
TRAC OFFS SIZE 1548 392 FICH AVI CONT
          OBJE LECT bar TERM
          REND
ENDPLAY
*=================================================================
SUIT
Animation from alice file
ECHO
RESU ALIC GARD PSCR
SORT VISU NSTO 1
PLAY
CAME   1 EYE   5.00000E-01  5.00000E-02  7.03491E-01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
SCEN GEOM NAVI FREE
     ISO  FILL FIEL VITE SCAL USER PROG 0.20 PAS 0.20 2.80 TERM
          SUPP LECT bar TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS SIZE 1548 392 FICH AVI NOCL NFTO 161 FPS 25 KFRE 10
          COMP -1
          OBJE LECT bar TERM
          REND
FREQ 1
GOTR LOOP 159 OFFS SIZE 1548 392 FICH AVI CONT NOCL
          OBJE LECT bar TERM
          REND
GO
TRAC OFFS SIZE 1548 392 FICH AVI CONT
          OBJE LECT bar TERM
          REND
ENDPLAY
*=================================================================
SUIT
Post-treatment (time curves from alice file)
ECHO
RESU ALIC GARD PSCR
SORT GRAP
PERFO 'twad64.pun'
AXTE 1.0 'Time [s]'
COUR  1 'dx_p0'   DEPL COMP 1 NOEU LECT p0   TERM
COUR  2 'dx_pmid' DEPL COMP 1 NOEU LECT pmid TERM
COUR  3 'dx_p1'   DEPL COMP 1 NOEU LECT p1   TERM
COUR  4 'vx_p0'   VITE COMP 1 NOEU LECT p0   TERM
COUR  5 'vx_pmid' VITE COMP 1 NOEU LECT pmid TERM
COUR  6 'vx_p1'   VITE COMP 1 NOEU LECT p1   TERM
TRAC 1 2 3 AXES 1.0 'DISPL. [M]'
TRAC 4 5 6 AXES 1.0 'VELOC. [M/S]'
LIST 1 2 3 AXES 1.0 'DISPL. [M]'
LIST 4 5 6 AXES 1.0 'VELOC. [M/S]'
QUAL DEPL COMP 1 LECT p0   TERM REFE  5.39339E-4 TOLE 5.E-3
     DEPL COMP 1 LECT pmid TERM REFE  2.87151E-4 TOLE 5.E-3
     DEPL COMP 1 LECT p1   TERM REFE  0.00000E+0 TOLE 5.E-3
     VITE COMP 1 LECT p0   TERM REFE  2.03415E+0 TOLE 5.E-3
     VITE COMP 1 LECT pmid TERM REFE  2.56695E+0 TOLE 5.E-3
     VITE COMP 1 LECT p1   TERM REFE  0.00000E+0 TOLE 5.E-3
*=================================================================
FIN
```

twad72.epx

```
TWAD72
ECHO
!CONV win
LAGR CPLA
DIME
  FORC 2 TABL 1 2
  ADAP NPOI 182 Q41L 208 CL22 14 ENDA
TERM
GEOM LIBR POIN 22 Q41L 10 CL22 1 TERM
 0.0 0.0  0.1 0.0  0.2 0.0  0.3 0.0  0.4 0.0  0.5 0.0
          0.6 0.0  0.7 0.0  0.8 0.0  0.9 0.0  1.0 0.0
 0.0 0.1  0.1 0.1  0.2 0.1  0.3 0.1  0.4 0.1  0.5 0.1
          0.6 0.1  0.7 0.1  0.8 0.1  0.9 0.1  1.0 0.1
 1 2 13 12
 2 3 14 13
 3 4 15 14
 4 5 16 15
 5 6 17 16
 6 7 18 17
 7 8 19 18
 8 9 20 19
 9 10 21 20
 10 11 22 21
 12 1
COMP GROU 2 'bar'  LECT 1 PAS 1 10 TERM
            'clpr' LECT 11 TERM
     NGRO 5 'p0'   LECT 1  TERM
            'p0p'  LECT 12 TERM
            'pmid' LECT 6  TERM
            'p1'   LECT 11 TERM
            'p1p'  LECT 22 TERM
     EPAI 1.E-2 LECT bar _q41l TERM
WAVE 2 PLAN X 0 Y 0 NX 1 NY 0 T0 0 C 5000 MAXL 4 H1 0.15 H2 0.5
       PLAN X 1 Y 0 NX -1 NY 0 T0 0.2E-3 C 5000 MAXL 4 H1 0.15 H2 0.5
MATE VM23 RO 8000. YOUN 2.E11 NU 0.0 ELAS 2.E11
          TRAC 1 2.E11 1.D0
          LECT bar _q41l TERM
     IMPE PIMP RO 8000. PRES -1.E6
          LECT clpr _cl22 TERM
ECRI COOR DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO
     TFRE 1.E-3
     FICH ALIC FREQ 1
LINK COUP BLOQ 1 LECT p1 p1p TERM
OPTI NOTE STEP LIBR
 LOG 1 DPMA LNKS STAT
 ADAP DHAN VITE
CALC TINI 0. TEND 1.E-3
*=================================================================
PLAY
CAME   1 EYE   5.00000E-01  5.00000E-02  7.03491E-01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS SIZE 1548 392 FICH AVI NOCL NFTO 161 FPS 25 KFRE 10
          COMP -1
          OBJE LECT bar TERM
          REND
FREQ 1
GOTR LOOP 159 OFFS SIZE 1548 392 FICH AVI CONT NOCL
          OBJE LECT bar TERM
          REND
```

```
GO
TRAC OFFS SIZE 1548 392 FICH AVI CONT
          OBJE LECT bar TERM
          REND
ENDPLAY
*==================================================================
SUIT
Animation from alice file
ECHO
RESU ALIC GARD PSCR
SORT VISU NSTO 1
PLAY
CAME   1 EYE   5.00000E-01  5.00000E-02  7.03491E-01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
SCEN GEOM NAVI FREE
     ISO  FILL FIEL VITE SCAL USER PROG 0.20 PAS 0.20 2.80 TERM
          SUPP LECT bar TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS SIZE 1548 392 FICH AVI NOCL NFTO 161 FPS 25 KFRE 10
          COMP -1
          OBJE LECT bar TERM
          REND
FREQ 1
GOTR LOOP 159 OFFS SIZE 1548 392 FICH AVI CONT NOCL
          OBJE LECT bar TERM
          REND
GO
TRAC OFFS SIZE 1548 392 FICH AVI CONT
          OBJE LECT bar TERM
          REND
ENDPLAY
*==================================================================
SUIT
Post-treatment (time curves from alice file)
ECHO
RESU ALIC GARD PSCR
SORT GRAP
PERFO 'twad72.pun'
AXTE 1.0 'Time [s]'
COUR  1 'dx_p0'   DEPL COMP 1 NOEU LECT p0   TERM
COUR  2 'dx_pmid' DEPL COMP 1 NOEU LECT pmid TERM
COUR  3 'dx_p1'   DEPL COMP 1 NOEU LECT p1   TERM
COUR  4 'vx_p0'   VITE COMP 1 NOEU LECT p0   TERM
COUR  5 'vx_pmid' VITE COMP 1 NOEU LECT pmid TERM
COUR  6 'vx_p1'   VITE COMP 1 NOEU LECT p1   TERM
TRAC 1 2 3 AXES 1.0 'DISPL. [M]'
TRAC 4 5 6 AXES 1.0 'VELOC. [M/S]'
LIST 1 2 3 AXES 1.0 'DISPL. [M]'
LIST 4 5 6 AXES 1.0 'VELOC. [M/S]'
QUAL DEPL COMP 1 LECT p0   TERM REFE  5.39339E-4 TOLE 5.E-3
     DEPL COMP 1 LECT pmid TERM REFE  2.87151E-4 TOLE 5.E-3
     DEPL COMP 1 LECT p1   TERM REFE  0.00000E+0 TOLE 5.E-3
     VITE COMP 1 LECT p0   TERM REFE  2.03415E+0 TOLE 5.E-3
     VITE COMP 1 LECT pmid TERM REFE  2.56695E+0 TOLE 5.E-3
     VITE COMP 1 LECT p1   TERM REFE  0.00000E+0 TOLE 5.E-3
*==================================================================
FIN
```

twad82.epx

```
TWAD82
ECHO
!CONV win
LAGR CPLA
DIME
  FORC 2 TABL 1 2
  ADAP NPOI 182 Q41L 208 CL22 14 ENDA
TERM
GEOM LIBR POIN 22 Q41L 10 CL22 1 TERM
 0.0 0.0  0.1 0.0  0.2 0.0  0.3 0.0  0.4 0.0  0.5 0.0
          0.6 0.0  0.7 0.0  0.8 0.0  0.9 0.0  1.0 0.0
 0.0 0.1  0.1 0.1  0.2 0.1  0.3 0.1  0.4 0.1  0.5 0.1
          0.6 0.1  0.7 0.1  0.8 0.1  0.9 0.1  1.0 0.1
 1 2 13 12
 2 3 14 13
 3 4 15 14
 4 5 16 15
 5 6 17 16
 6 7 18 17
 7 8 19 18
 8 9 20 19
 9 10 21 20
 10 11 22 21
 12 1
COMP GROU 2 'bar'  LECT 1 PAS 1 10 TERM
            'clpr' LECT 11 TERM
     NGRO 5 'p0'   LECT 1  TERM
            'p0p'  LECT 12 TERM
            'pmid' LECT 6  TERM
            'p1'   LECT 11 TERM
            'p1p'  LECT 22 TERM
     EPAI 1.E-2 LECT bar _q41l TERM
WAVE 2 PLAN X 0 Y 0 NX 1 NY 0 T0 0 C 5000 MAXL 4 H1 0.15 H2 0.5
       PLAN X 1 Y 0 NX -1 NY 0 T0 0.2E-3 C 5000 MAXL 4 H1 0.15 H2 0.5
MATE VM23 RO 8000. YOUN 2.E11 NU 0.0 ELAS 2.E11
          TRAC 1 2.E11 1.D0
          LECT bar _q41l TERM
     IMPE PIMP RO 8000. PRES -1.E6
          LECT clpr _cl22 TERM
ECRI COOR DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO
     TFRE 1.E-3
     FICH ALIC FREQ 1
LINK COUP BLOQ 1 LECT p1 p1p TERM
OPTI NOTE STEP LIBR
 LOG 1 DPMA LNKS STAT
 ADAP DHAN
CALC TINI 0. TEND 1.E-3
*==================================================================
PLAY
CAME   1 EYE   5.00000E-01  5.00000E-02  7.03491E-01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS SIZE 1548 392 FICH AVI NOCL NFTO 161 FPS 25 KFRE 10
          COMP -1
          OBJE LECT bar TERM
          REND
FREQ 1
GOTR LOOP 159 OFFS SIZE 1548 392 FICH AVI CONT NOCL
          OBJE LECT bar TERM
          REND
GO
TRAC OFFS SIZE 1548 392 FICH AVI CONT
          OBJE LECT bar TERM
          REND
ENDPLAY
*==================================================================
SUIT
Animation from alice file
ECHO
RESU ALIC GARD PSCR
SORT VISU NSTO 1
PLAY
CAME   1 EYE   5.00000E-01  5.00000E-02  7.03491E-01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
SCEN GEOM NAVI FREE
     ISO  FILL FIEL VITE SCAL USER PROG 0.20 PAS 0.20 2.80 TERM
          SUPP LECT bar TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS SIZE 1548 392 FICH AVI NOCL NFTO 161 FPS 25 KFRE 10
          COMP -1
          OBJE LECT bar TERM
          REND
FREQ 1
GOTR LOOP 159 OFFS SIZE 1548 392 FICH AVI CONT NOCL
          OBJE LECT bar TERM
          REND
GO
TRAC OFFS SIZE 1548 392 FICH AVI CONT
          OBJE LECT bar TERM
          REND
ENDPLAY
*==================================================================
SUIT
Post-treatment (time curves from alice file)
ECHO
RESU ALIC GARD PSCR
SORT GRAP
PERFO 'twad82.pun'
AXTE 1.0 'Time [s]'
COUR  1 'dx_p0'   DEPL COMP 1 NOEU LECT p0   TERM
COUR  2 'dx_pmid' DEPL COMP 1 NOEU LECT pmid TERM
COUR  3 'dx_p1'   DEPL COMP 1 NOEU LECT p1   TERM
COUR  4 'vx_p0'   VITE COMP 1 NOEU LECT p0   TERM
COUR  5 'vx_pmid' VITE COMP 1 NOEU LECT pmid TERM
COUR  6 'vx_p1'   VITE COMP 1 NOEU LECT p1   TERM
TRAC 1 2 3 AXES 1.0 'DISPL. [M]'
TRAC 4 5 6 AXES 1.0 'VELOC. [M/S]'
LIST 1 2 3 AXES 1.0 'DISPL. [M]'
LIST 4 5 6 AXES 1.0 'VELOC. [M/S]'
QUAL DEPL COMP 1 LECT p0   TERM REFE  5.39339E-4 TOLE 5.E-3
     DEPL COMP 1 LECT pmid TERM REFE  2.87151E-4 TOLE 5.E-3
     DEPL COMP 1 LECT p1   TERM REFE  0.00000E+0 TOLE 5.E-3
     VITE COMP 1 LECT p0   TERM REFE  2.03415E+0 TOLE 5.E-3
     VITE COMP 1 LECT pmid TERM REFE  2.56695E+0 TOLE 5.E-3
     VITE COMP 1 LECT p1   TERM REFE  0.00000E+0 TOLE 5.E-3
*==================================================================
FIN
```

twad92.epx

```
TWAD92
ECHO
!CONV win
LAGR CPLA
DIME
  FORC 2 TABL 1 2
  ADAP NPOI 182 Q41L 208 CL22 14 ENDA
TERM
GEOM LIBR POIN 22 Q41L 10 CL22 1 TERM
 0.0 0.0  0.1 0.0  0.2 0.0  0.3 0.0  0.4 0.0  0.5 0.0
          0.6 0.0  0.7 0.0  0.8 0.0  0.9 0.0  1.0 0.0
 0.0 0.1  0.1 0.1  0.2 0.1  0.3 0.1  0.4 0.1  0.5 0.1
          0.6 0.1  0.7 0.1  0.8 0.1  0.9 0.1  1.0 0.1
 1 2 13 12
 2 3 14 13
 3 4 15 14
 4 5 16 15
 5 6 17 16
 6 7 18 17
 7 8 19 18
 8 9 20 19
 9 10 21 20
 10 11 22 21
 12 1
COMP GROU 2 'bar'  LECT 1 PAS 1 10 TERM
            'clpr' LECT 11 TERM
     NGRO 5 'p0'   LECT 1  TERM
            'p0p'  LECT 12 TERM
            'pmid' LECT 6  TERM
            'p1'   LECT 11 TERM
            'p1p'  LECT 22 TERM
     EPAI 1.E-2 LECT bar _q41l TERM
WAVE 2 PLAN X 0 Y 0 NX 1 NY 0 T0 0 C 5000 MAXL 4 H1 0.15 H2 0.5
       PLAN X 1 Y 0 NX -1 NY 0 T0 0.2E-3 C 5000 MAXL 4 H1 0.15 H2 0.5
```

```
MATE VM23 RO 8000. YOUN 2.E11 NU 0.0 ELAS 2.E11
          TRAC 1 2.E11 1.D0
          LECT bar _q41l TERM
     IMPE PIMP RO 8000. PRES -1.E6
          LECT clpr _cl22 TERM
ECRI COOR DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO
     TFRE 1.E-3
     FICH ALIC FREQ 1
LINK COUP BLOQ 1 LECT p1 p1p TERM
OPTI NOTE STEP LIBR
 LOG 1 DPMA LNKS STAT
 ADAP WHAN
CALC TINI 0. TEND 1.E-3
*==================================================================
PLAY
CAME   1 EYE   5.00000E-01  5.00000E-02  7.03491E-01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS SIZE 1548 392 FICH AVI NOCL NFTO 161 FPS 25 KFRE 10
          COMP -1
          OBJE LECT bar TERM
          REND
FREQ 1
GOTR LOOP 159 OFFS SIZE 1548 392 FICH AVI CONT NOCL
          OBJE LECT bar TERM
          REND
GO
TRAC OFFS SIZE 1548 392 FICH AVI CONT
          OBJE LECT bar TERM
          REND
ENDPLAY
*==================================================================
SUIT
Animation from alice file
ECHO
RESU ALIC GARD PSCR
SORT VISU NSTO 1
PLAY
CAME   1 EYE   5.00000E-01  5.00000E-02  7.03491E-01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
SCEN GEOM NAVI FREE
     ISO  FILL FIEL VITE SCAL USER PROG 0.20 PAS 0.20 2.80 TERM
          SUPP LECT bar TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS SIZE 1548 392 FICH AVI NOCL NFTO 161 FPS 25 KFRE 10
          COMP -1
          OBJE LECT bar TERM
          REND
FREQ 1
GOTR LOOP 159 OFFS SIZE 1548 392 FICH AVI CONT NOCL
          OBJE LECT bar TERM
          REND
GO
TRAC OFFS SIZE 1548 392 FICH AVI CONT
          OBJE LECT bar TERM
          REND
ENDPLAY
*==================================================================
SUIT
Post-treatment (time curves from alice file)
ECHO
RESU ALIC GARD PSCR
SORT GRAP
PERFO 'twad92.pun'
AXTE 1.0 'Time [s]'
COUR  1 'dx_p0'   DEPL COMP 1 NOEU LECT p0   TERM
COUR  2 'dx_pmid' DEPL COMP 1 NOEU LECT pmid TERM
COUR  3 'dx_p1'   DEPL COMP 1 NOEU LECT p1   TERM
COUR  4 'vx_p0'   VITE COMP 1 NOEU LECT p0   TERM
COUR  5 'vx_pmid' VITE COMP 1 NOEU LECT pmid TERM
COUR  6 'vx_p1'   VITE COMP 1 NOEU LECT p1   TERM
TRAC 1 2 3 AXES 1.0 'DISPL. [M]'
TRAC 4 5 6 AXES 1.0 'VELOC. [M/S]'
LIST 1 2 3 AXES 1.0 'DISPL. [M]'
LIST 4 5 6 AXES 1.0 'VELOC. [M/S]'
RCOU 11 'dx_p0' FICH 'twad12.pun' RENA 'dx_p0_12'
RCOU 12 'dx_pmid' FICH 'twad12.pun' RENA 'dx_pmid_12'
RCOU 13 'dx_p1' FICH 'twad12.pun' RENA 'dx_p1_12'
RCOU 14 'vx_p0' FICH 'twad12.pun' RENA 'vx_p0_12'
RCOU 15 'vx_pmid' FICH 'twad12.pun' RENA 'vx_pmid_12'
RCOU 16 'vx_p1' FICH 'twad12.pun' RENA 'vx_p1_12'
TRAC 1 2 3 11 12 13 AXES 1.0 'DISPL. [M]'
COLO NOIR NOIR NOIR ROUG ROUG ROUG
TRAC 4 5 6 14 15 16 AXES 1.0 'VELOC. [M/S]'
COLO NOIR NOIR NOIR ROUG ROUG ROUG
QUAL DEPL COMP 1 LECT p0   TERM REFE  5.39339E-4 TOLE 5.E-3
     DEPL COMP 1 LECT pmid TERM REFE  2.87151E-4 TOLE 5.E-3
     DEPL COMP 1 LECT p1   TERM REFE  0.00000E+0 TOLE 5.E-3
     VITE COMP 1 LECT p0   TERM REFE  2.03415E+0 TOLE 5.E-3
     VITE COMP 1 LECT pmid TERM REFE  2.56695E+0 TOLE 5.E-3
     VITE COMP 1 LECT p1   TERM REFE  0.00000E+0 TOLE 5.E-3
*==================================================================
FIN
```

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